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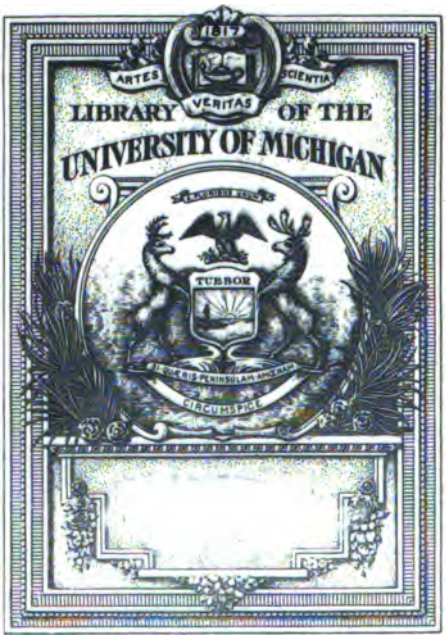

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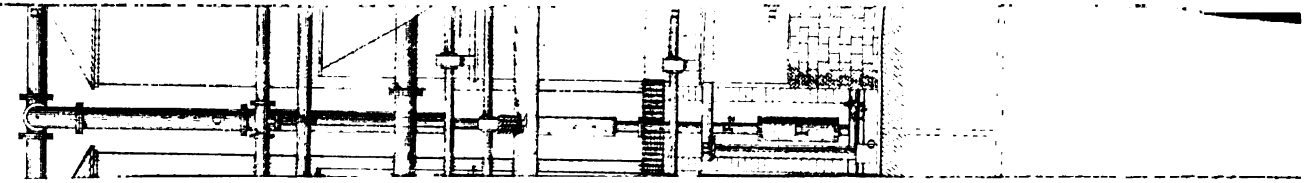

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REPORTS

OF THE

UNITED STATES COMMISSIONERS

TO THE

PARIS UNIVERSAL EXPOSITION,

1878.

PUBLISHED UNDER DIRECTION OF THE SECRETARY OF STATE BY AUTHORITY OF CONGRESS.

VOLUME IV.

CHEMICAL PROCESSES, MINING INDUSTRIES, STEAM AND GAS ENGINES, MACHINES AND MACHINE TOOLS, CLOCKS AND WATCHES, RAILWAY APPARATUS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1880.

GIFT
DEAN M. E. COOLEY
9-22-1932

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CHEMICAL AND PHARMACEUTICAL PROCESSES AND PREPARATIONS.

THOMAS E. JENKINS, M. D.

1 P R——VOL 4

To Hon. R. C. McCORMICK,

Commissioner-General:

SIR: I have the honor to send you herewith the report of Dr. Thomas E. Jenkins, Commissioner of the United States from Kentucky to the Paris Exposition of 1878, as member of the International Jury of Recompenses in the Jury of Class 47.

During his last illness Dr. Jenkins sent for me and placed his report in my hands, with the request that I revise and prepare it for publication. In fulfilling his commission I have been able to do very little more than make some slight changes in nomenclature—suggested by him—and arrange the sheets in the proper order.

Very respectfully,

SAM. G. STEVENS.

[Extract from the Official Classification.]

CLASS 47.—CHEMICAL AND PHARMACEUTICAL PRODUCTS.

Acids, alkalies, salts of all kinds. Sea-salt and products extracted from mother-water.

Various products of chemistry: wax and fatty substances; soaps and candles; raw materials used in perfumery; resins, tar, and the products derived from them; essences and varnishes; various coating substances; blacking. Objects made of india-rubber and gutta-percha; dyes and colors.

Mineral waters and natural and artificial aërated waters. Raw materials used in pharmacy. Medicines, simple and made up.

CLASS 53.—APPARATUS USED IN CHEMISTRY, PHARMACY, AND TANNING.

Laboratory utensils and apparatus.

Apparatus and instruments used in assays for industrial and commercial purposes.

Process and appliances used in the manufacture of chemicals, forges, and candles.

Processes and apparatus used in the manufacture of essences, varnishes, and articles made of india-rubber and gutta-percha.

Processes and apparatus used in gas works.

Processes and apparatus used in bleaching.

Processes used in the preparation of pharmaceutical products.

Processes used in tan-yards and in leather-dressing.

Processes and apparatus used in glass works and in china and earthenware manufactories.

REPORT

ON

CHEMICAL AND PHARMACEUTICAL PROCESSES AND PREPARATIONS.

INTRODUCTION.

Reference to previous "World's Fairs."

Seven world's fairs have been held since the Crystal Palace was erected in Hyde Park in 1851, at intervals of two, three, four, five, and seven years, which have progressively grown in extent, comprehensiveness, variety, interest, magnificence, importance, and usefulness, until the present Exposition at Paris opened upon the world with its unprecedented exhibition of the results of the genius, skill, and industry of all peoples, surpassing all its predecessors in magnitude and in splendor, and serving as a monument to the wisdom and taste of the people who stand first among nations in the material industries as well as in literature and art.

The Paris Exposition unprecedented in extent and splendor.

Short interval between exhibitions limits the extent of novelties presented.

The frequency of these peaceful international contests for supremacy in the useful arts leaves little time between any two of them for the manifestation of any general striking progress in the industrial arts; still, the sharp competition, especially between the different European countries, resulting from the desperate struggle for existence during the few years just passed, like necessity, has compelled a progress which is apparent even to the casual observer as he runs through the vast collections displayed at Paris this year. Products are here seen to-day to be greatly improved over those shown at the last Exposition held in this city, and at the same time prices in most instances have fallen to a surprisingly low figure in the case of many of the articles of daily and general use. With some the quality has been improved and the old prices sustained; with others the quality has remained stationary while the prices have gone down; with others again there is observed an improvement in quality and a depression in prices; and a few are stationary in both respects. Speaking of the materials which are to be comprehended in the scope of this report, it is to be remarked that the greatest improvement in the

Progress very apparent nevertheless.

Great cheapening of products, and improvement in quality.

Improvement in quality and diminished price especially noticeable in tinctorial substances and utilization of waste products.

quality of the products, together with the greatest fall in prices, is noticed in the case of the newly discovered tinctorial substances, and matters derived from what are termed waste products of chemical manufactures. All this seems to show that technical chemistry is much better understood and more successfully practiced to-day than formerly, and foreshadows the rapid progress to be made in the near future in the industrial arts, through the guidance of this marvellous science. Chemistry is no longer the occult magic of the middle ages; it is the most luminous of the true sciences, and is destined ere long as the means of elucidating much if not all the obscure phenomena of nature. The veil which till lately was carefully thrown around all chemical processes, and all manufactures involving chemical laws and reactions, is rapidly being drawn aside and disclosing the secrets of the few for the benefit of the many. Practical experiments and discoveries in the chemical arts are being described and patented, and constantly important technical memoirs are read before the scientific societies of the world. This is real material progress, which must inevitably exert a vast influence in the amelioration of the condition of mankind.

Chemistry the most luminous of the true sciences.

Extent and importance of the subject of this report.

In transmitting this report, the writer feels that he has been treating a subject of vast extent and importance in itself, and one destined to exercise an influence in the material destinies of our nation of which it is now impossible to form an adequate idea; a subject which deserves and should receive much more attention than has hitherto been bestowed upon it. In view of its magnitude, the multitudinous character of the exhibits relating to it at the Exposition, and the shortness of time allotted for the examination of them, he feels that no more than the most elementary and superficial survey can be hoped for.

Exhibits in this class scattered over the whole area of the grounds.

In order to get a view of all the exhibits in Class 47 it was necessary to visit every portion of the immense building known as the *Palais du Champ de Mars*, as well as scores of annexes and outbuildings erected by the several represented countries in different parts of the field and in the inclosure of the *Trocadéro*. A leisurely walk through them all required the whole time of several days, and to make a general and particular examination of all the exhibits demanded the attention of many weeks; and I think it safe to say that no one has succeeded in seeing them all, much less has he been able to subject them to a close or critical examination and study. It was, therefore, considered an almost hopeless task to undertake to make a thorough and exhaustive report on all matters comprehended in the classes

Hopeless to make an exhaustive report.

through which chemical and pharmaceutical subjects were scattered.

Difficulty in obtaining satisfactory information.

Commissioners were invested with no power or authority by which they could command facilities for obtaining satisfactory information in regard to statistics and processes of manufacture, and consequently they had to rely to a great extent, for the most valuable portions of their reports, on the gratuitous, meager, and uncertain statements made by exhibitors. Members of the jury, however, had access to the necessary facts and data for the formation of a useful report, but the examinations made by the jury were made for the purpose of apportioning awards, rather than for framing a report, and their visits were crowded into the short space of six weeks; consequently their work was too much hurried for purposes of a report. During the fervent summer weather, too, members found themselves exhausted with fatigue before they could begin really to execute their official duties in anything like a regular and systematic manner.

The opportunities and duty of the jury.

Composition of the jury.

The International Jury of Recompenses of the Paris Exposition of 1878 was composed of 750 (and 350 supplementary) members, who were selected on account of special fitness for the respective classes to which they were assigned from the different countries represented at the Exhibition, and appointed by the administration of the great fair on the recommendation of the officials of the various countries.

The jury in class 47: Chemical Products.

The jury of Class 47, which comprehended chemical and pharmaceutical preparations, was composed as follows:

Prof. ROSCOE, F. R. S.	England and her colonies.
THOMAS E. JENKINS, M. D	United States.
L. MONRAD-KROHN	Sweden and Norway.
Prof. A. COSSA	Italy.
M. MATCHECO	Austria and Hungary.
Prof. F. BEILSTEIN	Russia.
Prof. PICARD	Switzerland.
Prof. P. DEWILDE	Belgium.
V. JOERGENSEN	Denmark.
M. TORRES-CAICEDO, *Minister Plenipotentiary of Salvador*	South and Central America.
Prof. R. D. SILVA	Portugal.
M. SERRURIER	Holland and her colonies.
M. BERTHELOT	France.
M. FOURCADE	France.
M. L. CHIRIS	France.
M. C. LAUTH	France.
M. TROOST	France.
M. SCHLŒSING	France.
M. J. FRANÇOIS	France.

Jury in class 47: Chemical Products.

M. FERRAND.....France.
M. GUIBAL.....France.
M. RENARD.....France.
M. CHEVALIER-ESCOT.....France.

SUPPLEMENTARY JURORS.

M. Ph. de CLERMONT.....France.
M. JUNGFLEISCH.....France.
M. BONDÉ.....France.
M. L. BRUN.....France.
M. GODEFROY (expert).....Austria.

The nature and necessary limitations of the jury work.

The work of the jury was arduous, earnest, and gratuitous; but, from the nature and magnitude of the Exhibition, it was of necessity rapid and superficial, and it was natural under the circumstances to hear of cases of under and over valuation or estimation of exhibits. This was unavoidable. It has always happened, and in all probability always will. The reasons are numerous and obvious, and for the benefit of future exhibitors at world's fairs it may not be out of place to mention a few of them.

The multitude of exhibitors in the class, and the numerous articles in each exhibit.

The jury was expected to examine every article in the displays of the many hundreds, and in many cases of thousands, of exhibitors in a class, and to read descriptive circulars and pamphlets issued in connection with them. Afterwards these exhibits had to be subjected to a general comparison, and each one assigned its proper place in the order of merit; and to do all this six weeks only were allowed. A few figures will quickly show the physical impossibility of making any serious examination of all exhibits. Taking a class in which two thousand exhibits are catalogued, and allowing each exhibit to contain fifty separate articles,* would give one hundred thousand articles to be examined; and a jury working four hours per day would be required to examine over ten articles per minute in order to complete the list in the space of six weeks.

Defective labeling and absence, or ignorance of custodians of exhibits.

In the next place, want of facilities for rapid jury work was frequently encountered, owing to defective labeling, the absence or ignorance of the custodian of exhibits, incomplete or defective descriptive lists, inaccessibility of exhibits, incorrect classification of exhibits in the official catalogues, misplacing of exhibits.† Some manufacturers guarded

* Exhibits of chemical and pharmaceutical preparations averaged more than fifty to a case; one exhibit from the United States, in Class 47, contained above a thousand separate articles.

† One instance is known where the exhibit was regularly catalogued in Class 47, but was not found until the jury had finished its labors, when it was discovered in the hands of an exhibitor of steam-machinery in Class 54, who was using the article for the purpose of lubricating his engine, for which purpose, he stated, it was well adapted.

so jealously their processes and apparatus that no adequate idea could be got by the jury upon which to base a rational opinion of articles exhibited. In many instances no facilities for a close and critical examination of the articles were accorded, but evasive and sometimes misleading replies were given to the questions of the jurors. In many instances no statistics of manufactures could be obtained, and occasionally when given they were found to be unreasonable exaggerations, unworthy of credit, and rendering the exhibitor liable to be passed without recognition.

The secrecy observed in some processes.

The following is a tabular statement of the different countries which were represented at the Paris Exposition, 1878, in Group V, Class 47, with the number of exhibitors from each, the number of recompenses awarded to each, and the proportion of awards to the number of exhibitors:

Tabular statement of the countries represented in the class.

The number of exhibitors and of awards in the class.

	No. of exhibitors.	No. of awards.	Percentage of recompenses.
Austria-Hungary	156	83	53
Belgium	53	44	83
China	16	2	12.5
Denmark	16	6	37.5
France and French colonies, including Algeria	561	480	85.5
British Empire	117	96	82.
Holland and colonies	51	25	49.
Italy	123	57	46.3
Japan	8	4	50.
Luxembourg	3	1	33.3
Norway	28	13	46.4
Persia	1	.....	.....
Portugal and colonies	58	21	36.2
Russia	51	43	84.3
Spain	125	81	64.8
Sweden	18	12	66.6
South and Central America	57	42	73.7
Switzerland	31	20	64.5
Tunis	2	.....	.....
United States	42	39	93.
	1,517	1,069	70.4

Whole number of exhibitors	1,517
Whole number of awards	1,069
Proportion of awards to exhibitors (per cent.)	70.4

Significance of the data in the table above.

The significance of this table is apparent and no comment is necessary; but it may be worth while to call attention to a few facts relating to the part the United States took in this world's fair, and the odds with which her exhibitors had to contend in the competition for recognition at the Exposition of Paris.

Difficulties attending the exhibition from the United States.

In the first place, the act of Congress providing for an appropriation and a commission to attend to the interests of citizens desiring to send their exhibits abroad, was passed at so late a day that adequate time was not afforded

Difficulties attending the exhibition from the United States.

for exhibitors to prepare objects suitable for display before judges of picked men from all parts of the world; and many manufacturers, some of whom were the largest and most important in the country, were deterred from sending their productions at all. Again, the meagerness of the appropriation was out of all proportion to the importance of an enterprise which should have been carried out on the grandest possible and on the most magnificent scale, since the prestige gained at Philadelphia was to be maintained. Unfortunately, the United States, as represented in Class 47, did not meet the expectations of Europe at Paris. Many of our leading and most extensive manufacturers, who figured so conspicuously at the Centennial Exhibition, were not represented at the Paris Exposition; the grand displays of chemicals, which attracted so much attention, excited so much interest, and received so much praise at Philadelphia in 1876, were absent from the building in the *Champ de Mars* in 1878.

Delay and meagerness of the appropriation.

The prestige of America at the "Centennial" not maintained in Paris.

The nature of our contest with the European scientists and manufacturers.

In the second place, it should not be forgotten that our countrymen, with their very partial show in Class 47, had to contend against France, the mother of modern chemistry; England, the giant producer of chemical products; and Belgium and Switzerland, the very bee-hives of scientific industry. Notwithstanding all these odds against us, the tabulated statement above, which is made up from the Official Catalogue and the Official List of Recompenses, shows that the proportion of the number of recompenses awarded to the United States in the class of chemical and pharmaceutical products is 22 per cent. higher than the average of awards in the same class to all countries represented; 7.5 per cent. higher than France; 11 per cent. higher than England; 10 per cent. higher than Belgium, and 28.4 per cent. higher than Switzerland.

The relative percentage of awards to United States exhibitors.

These remarks are not made in any boastful spirit, but simply as a matter of congratulation to the intelligent and industrious citizens of our country, who need only the assurance, which is best given in a great international contest like the one just past, that they can successfully compete with the world, to stimulate them to accomplish that success. It is very evident that what is most needed in the near future is a foreign market for our surplus products of manufacture, not only those represented in Class 47, but in many other classes; for manufacturing countries have, or will, shut their doors against American goods, as France has already done in the case of many articles manufactured on this side of the Atlantic.

Our future necessity for a foreign market

SULPHURIC ACID.

Sulphuric acid.

The manufacture of sulphuric acid has increased at a most rapid rate during late years. Furnishing as it does the most reliable index of the growth and extent of the chemical arts in general, the enormous advance made in this branch affords a most satisfactory indication of the present condition of industrial chemistry. In France the production of sulphuric acid has increased from 90,000,000 kilograms in 1867 to 150,000,000 kilos in 1877. Two years previous the total European production was estimated by Diete at 840,000,000 kilos, distributed as follows:

French production.

	Kilos.
England	500,000,000
France	150,000,000
Germany	105,000,000
Austria	40,000,000
Belgium	30,000,000
Other countries	15,000,000

European production.

English production.

England at present produces over 16,000,000 kilos weekly. Roscoe puts down the annual production at 850,000 tons. Angus Smith in 1877 estimated the amount of sulphur required for the sulphuric acid used in the preparation of artificial fertilizers at 100,000,000 kilos, and for the sulphuric acid used in soda works and in other industries at 160,000,000 kilos; the total equivalent to 575,000,000 kilos of pyrites.

Sources of sulphurous acid.

Sources of sulphuric acid.

Sulphur replaced in Europe by pyrites.

The chief source of sulphurous acid—sulphur—is now almost entirely replaced by iron and copper pyrites. The leading exception is to be found in this country, where the distance of pyrites mines from manufacturing centers prevents competition with sulphur derived from Sicily or the newly-discovered deposits in the Sierra Nevada and the adjacent region. The principal sources of pyrites in Europe are Spain, whose annual production is in round numbers 440,000,000 kilos, averaging 48 per cent. of sulphur; Great Britain, 59,000,000 kilos; France, 178,400,000 kilos, containing 46 per cent. of sulphur; Portugal, 180,330,000 kilos of 49 per cent.; Norway, 71,660,000 kilos, of 40 per cent.; Belgium, 45,000,000 kilos, of 45 per cent.; Italy, 3,000,000 kilos, of 48 per cent.; Prussia, 128,000,000 kilos, of 42 per cent. Large deposits of a very pure mineral have recently been discovered in Lower Styria and the Satzkammergut, in the Austrian Empire, and extensive mines have lately been opened in canton Valais, in Switzerland, yielding pyrites containing

Sources of pyrites in Europe.

Late discoveries of pure mineral.

Sulphuric acid. 35 per cent. of sulphur, while those now worked in Sweden furnish a mineral whose proportion of sulphur is 41 per

Sources other than pyrites. cent. Other and more limited sources of sulphurous acid are blende, the residues from the wasting of galena, mixtures of sulphate of zinc and zinc blende, the sulphur obtained by Laming's method from gas works, the sulphureted hydrogen set free in the manufacture of ammonium sulphate, and conducted into the pyrites ovens, and the preparation of silicates in the manufacture of glass by the fusion of sodium sulphate and lime with coal and silica:

$$2Na_2SO_4+C+2SiO_2=2Na_2SiO_3+2SO_2+CO_2.$$

Chemically pure sulphuric acid. For the manufacture of pure sulphuric acid it is still necessary in most cases to use sulphur, for the reason that nearly all pyrites contain more or less arsenic. Sulphuric acid of this country is made from sulphur and is free from arsenical contamination.

Pyrites burners.

Pyrites furnaces. Pyrites furnaces are divided into two classes, according as they are intended to burn lumps of the ore or fine fragments and powder.

Lump burners. The burners used for the lumps show but little variety of form, and no notable changes have been introduced of late in their construction. All unite in burning the pyrites on

English. fire-bars. The English burners consist of a number of small kilns separated from each other by vaulted compartments, each being filled and emptied independently of the

French. others. In the French burners the most noticeable feature is the rotary fire-bars, permitting an easy gradual removal of the lower layers of spent ore. In Belgian burners the

Belgian. grates are immovable, and the spent ore is raked out with long hooks by workmen who enter a roomy passage be-

German. neath the ovens. The German ovens combine, as a rule, the essential features of the French and Belgian furnaces. The chief points of a good furnace, viz, ease and rapidity of charging, ability to remove the residues gradually and without loss of sulphurous acid, and a consumption of the sulphur in the pyrites so complete that not more than 3 per cent. remain in the spent ore, are attained in nearly all

Annular furnaces. forms used. The introduction of annular furnaces, based on much the same principles as Hofman's circular kilns, by De Hemptinne and Bode, is the only noticeable improve-

Bode's oven. ment. In Bode's oven, which has not yet been described in detail, although in satisfactory operation in several estab lishments, the amount of residual sulphur in the spent ores

Sulphuric acid.

is not above one per cent. The pyrites powder or "smalls," which forms an important fraction of the ore as delivered from the mines, has presented many difficulties to the manufacturer, most of which are now successfully overcome. When burned with the lumps in the usual kilns, the fine powder chokes the draft to such an extent that a large percentage of sulphur remains in the residual ores. In order to remedy this defect, the "smalls" have, especially in England, been frequently molded into balls by means of water, with more or less clay, and then burnt in the kilns for lumps. This practice, except in England, is almost entirely supplanted by the use of special furnaces, most of which aim at a constant movement of the burning mass, the combustion frequently being at the same time aided by the passage of the hot gases issuing from the ordinary kilns. Gerstenhöfer's furnace, introduced in 1862, has been extensively used for this purpose, chiefly in Germany. In this furnace the ores are admitted into a shaft, heated at the start, in which triangular prisms of fire-clay are so arranged that the pyrites slowly descend from top to bottom, constantly exposing by the movement fresh surfaces for combustion to the entering air. The advantages of this disposition are a minimum of labor, ability to burn poor ores without fuel, continuous working, and a yield of rich gases for the vitriol chambers. Its disadvantages are an incomplete oxidation of the sulphur, and the presence of such quantities of flue-dust in the gases given off that the acid is not only rendered impure, but the platinum concentrators are rapidly worn down by the movement of the sharp-edged crystals of sulphate of iron formed in the liquid. These drawbacks have caused the furnace to be superseded by other forms in most cases, except in the treatment of very poor ores, when its peculiar structure enables it to successfully maintain its ground.

Bode's oven.

Supplanted except in England.

Gerstenhöfer's furnace.

Perret's Burner, used for a number of years in France, was mounted above the usual oven for lumps, and consisted essentially of a series of horizontal plates covered with a layer of "smalls," over each of which the hot gases of the furnace below were forced to pass on their way to the chambers. The sulphur present was reduced by this means to 5 per cent. More recent and simplified forms of this furnace are said to give better results.

Perret's burner.

A happy modification of Perret's furnace was introduced by M. Maletra a few years ago at Rouen, in which the ores, introduced above by a funnel, are forced to descend through a series of plates by being pushed from one plate to the one

Maletra's modification of Perret's furnace.

Sulphuric acid.

Maletra's furnace.

next lower. After the furnace has been heated the combustion is maintained without fuel. On account of its simplicity, independence of the lump furnaces, and cheapness, the use of this furnace has spread rapidly and it has taken a firm foothold in Germany, where Bode, Hofmann, and Kunheim have greatly perfected its construction. By its means

Economy of the process.

the amount of residual sulphur in the spent ores is reduced to 1½ per cent. in France and Germany and 1 per cent. in Switzerland, and lumps possessing a diameter of not over 17 millimeters can easily be burnt with the powder.

Hasenclever & Helbig's furnace.

The furnace introduced by Hasenclever & Helbig in 1870, and modified in 1876, is used to a certain extent in Germany, although its more complicated character renders it in many respects less efficient than the Maletra furnace. The ores, on entering it, pursue a zigzag course through five vertical compartments, separated from each other by divisions consisting of a succession of long, narrow plates placed at right angles to each other. An ingenious but complicated arrangement for warming the air admitted by the heat abstracted from the products of combustion permits the latter to be maintained without external aid, and vastly economizes the resultant heat. One objection to the furnace is the rapid accumulation of fine dust in the tubes serving for the exit of the gases.

Walker burner.

The Walker Burner, introduced about five years ago in Belgium, is designed especially for burning fragments from 1½ to 12 millimeters in diameter. It consists of nine separate furnaces, so arranged that the gases pass from one through the other, while each one can be shut out of the circuit for the purpose of emptying and filling. The grates consist of movable fire-bars, and have each a surface of three square meters, permitting the combustion of 10,000 in 24 hours. The layer of pyrites is not more than 15 centimeters in depth, and the amount of sulphur in the ore is reduced from 42 to 3½ per cent. The gases can be led into a plate furnace to effect the combustion of "smalls." This system is thus far in but limited use.

Spencer's muffle furnace.

Spencer's Muffle Furnace is still in use in some English establishments in a modified form, the pyrites being pushed from one plate to another, as in the Maletra apparatus. It leaves 2½ per cent. of sulphur in the ores treated by it.

Rotary furnaces.

Various attempts have been made to introduce mechanical furnaces for the combustion of pyrites. Revolving furnaces have long been in successful operation for the expulsion of the sulphur contained in ores of valuable metals, but as yet no system has found general adoption for the

simple production of sulphurous acid. The rotary furnace invented by Perret, consisting of a cylinder moving about an axis slightly inclined, and causing a slow descent of the pyrites through its various compartments, has not been found practical in the application.

Sulphuric acid.

Perret's rotary furnace.

The mechanical furnace lately introduced by MacDougall in England, and now in operation in several establishments, appears to give better satisfaction. It consists of an iron cylinder, lined with fire-brick, and divided into compartments by a number of horizontal perforated plates; an axle passing through the center is provided with arms sweeping over the surface of each compartment; pyrites powder, entering from above, descends more or less rapidly through the cylinder according to the speed imparted to the axle. After the furnace is once heated a blast of air is all that is needed to maintain combustion. The residual sulphur is reduced to 1 per cent. by this system, at an expense of about $1 per ton. The chief disadvantage in the working of MacDougall's furnace is the enormous amount of flue-dust in the gases which issue from it. The attempts made to free them from the dust by passage through water have the effect of cooling the gases to a temperature too low for satisfactory operation in a Glover's tower.

MacDougall's rotary furnace.

Hasenclever & Helbig's furnace for utilizing the sulphur in zinc blende is, with some slight modification, still in extensive use.

Utilization of the residues from the pyrites burners.

Utilization of residues from the pyrites burners.

Since the extensive introduction of Spanish and Portuguese pyrites into the manufacture of sulphuric acid the extraction of the copper and silver remaining in the residues has become an important factor of the process, especially in England, where the use of copper pyrites is now so widely spread. The residues from the German works were formerly sent directly to England for further treatment; now they are chiefly submitted to the first stage of the English process, and the mixture of copper and the precious metals is sent to England for their final separation.

The copper pyrites used in England loses about 30 per cent. of its weight in heating, and the residues contain 0.0025–0.0037 per cent. of silver, and 0.000037 per cent. of gold, 1.55 per cent. of copper in combination with sulphur, and 2.17 per cent. in union with oxygen. After calcination with salt in a muffle or in an ordinary furnace, the copper is precipitated from the solution of its chlorides with metallic iron. Experience has not yet shown whether spongy iron is to be

Silver, gold, and copper in the pyrites used in England.

Process of extracting.

Sulphuric acid.

preferred to scrap-iron for this purpose. With very carefully constructed furnaces, the former seems to be more economical. Gibb & Giltharp's revolving furnace, despite its expensive construction, is still regarded as the most efficient for purposes of calcination. The method for separating the copper, introduced by the same persons, has been relinquished after a lengthy trial and replaced by the usual treatment with iron. It consisted essentially in using exactly enough salt to effect the transportation of the copper into its chlorides, thus forming a pure sulphate of sodium, and precipitation of the copper as sulphide from its solution by means of sulphureted hydrogen, obtained by first reducing the sulphate of sodium to sulphide, and introducing carbon dioxide into the solution of the latter, the soda thus formed being naturally utilized. The expense of evaporating the enormous amount of water required in the process has caused it to be abandoned. The copper solutions are now entirely freed from arsenic by neutralization with lime, which causes a precipitation of arsenite of iron.

Process of extracting valuable metallic residues of pyrites burning.

Gibb & Giltharp's revolving furnace for extracting copper.

Extraction of silver from spent ore.

The extraction of the silver in the spent ores is now pursued in a very rational manner. Claudet's method, based on the precipitation of the silver as iodide from the solution of the calcined ores with iodide of potassium, has now a comparatively limited use, being supplanted by Gibb's process, introduced in 1875. The latter is based on the fact that when sulphureted hydrogen is introduced into the solution of a cupric salt containing small quantities of silver the greater portion of the latter is precipitated with the first portion of the sulphide of copper. By causing a partial precipitation of the solution, amounting to about 6 per cent. of the copper present, a precipitate is obtained containing 0.6 per cent. of silver, which is profitably separated from the accompanying copper, lead, and other compounds. The sulphureted hydrogen used in this process is obtained from the waste products of soda works.

Claudet's method supplanted by Gibb's process.

Use of spent ores in iron manufacture.

The practicability of using the spent ores from pyrites furnaces for the manufacture of iron has been satisfactorily shown in a number of manufacturing centers. The residues of the copper pyrites, after having undergone the treatment above described, are found to be well adapted for reduction in a blast furnace. Especially since the introduction of Maletra's furnace the percentage of sulphur remaining in ordinary iron pyrites after burning is so small that the residues can be employed to good effect in the manufacture of Bessemer metal. This is notably the case with the spent

In the manufacture of Bessemer steel.

ores of Westphalian pyrites, which are entirely free from phosphorus and copper. *Sulphuric acid.*

The entire absence of arsenic from these pyrites should also render them exceedingly valuable for the manufacture of pure sulphuric acid. The use of the residual oxide of iron for pigments has assumed large proportions in England and Germany. Tcherniac's newly introduced process for the manufacture of ferro-cyanide of potassium by synthesis includes likewise the use of finely divided iron, obtained by the reduction of the pyrites residues with coal. Value of Westphalian pyrites. Pigments from residual oxide of iron.

P. W. Hofmann has made some interesting experiments on the residues from the Meggen pyrites, which are used by a number of German establishments. He finds that the large percentage of sulphur remaining in the spent ores is due to the presence of zinc, with which it is united in the form of sulphate. The residues are exhausted by lixiviation, and salt is added to the concentrated solution of sulphates of iron and zinc at 30° C. Pure sulphate of sodium crystallizes out on cooling, and by further evaporation the solution of chloride of zinc is freed from all other salts present. The residues from the lixiviation still contain sulphur, but it has been observed that those portions entirely free from sulphur form a light friable mass, which with a sieve can be easily separated from the more compact fragments, still containing more or less sulphide, and be utilized in the blast furnace. Hofman's experiments with Meggen pyrites.

Vitriol chambers. Vitriol chambers.

The composition of the gases entering the lead chambers has been the subject of careful experiment, especially with reference to the presence and cause of the vapors of sulphuric anhydride. Lunge has shown that in the gases resulting from the combination of Spanish pyrites 6 per cent. of the sulphur present is in the form of SO_3. If these gases are conducted over a layer of heated oxide of iron, the percentage increases to 18 per cent.—a result tending to support the assumption that the SO_3 arises from the oxidation in the furnace of the SO_2 at the expense of the oxide of iron formed from the partial combustion. Source of the sulphuric anhydride.

The reactions taking place in the lead chambers have not been the subject of investigation during the past few years.

Nitric acid is now generally introduced in a gaseous state. The method prevalent in England is to let the hot gases issuing from the burners pass over troughs holding from 12 to 24 kilos of nitrate of soda; sulphuric acid is slowly admitted through a lead funnel, and the vapors of the nitric acid are led directly into the lead chambers, or, more rarely, Nitric acid introduced in gaseous form.

Sulphuric acid. accompany the sulphurous acid through the Glover's tower. The liquid bisulphate of soda remaining in the troughs is drawn off through a tube opening in its lower surface, and closed with a conical stopper. Simple arrangements permit the filling of the troughs, as well as the agitation of their contents, without loss of sulphurous acid. In most English establishments the amount of nitrate of sodium used is from 3 to 6 per cent. of the amount of sulphur present in the pyrites. The best conducted of them bring this quantity down to 2 per cent.

Reactions in the lead chambers.

New sources of nitrous vapors.

New sources of nitrous vapors have been found in the residual acids of aniline and nitro-glycerine works, which yield large quantities of nitrogen compounds when passed through a Glover's tower. One English establishment claims to have obtained good results for two years past by introducing a solution of nitrate of soda directly into the chambers by means of a jet of steam.

Sprengel's steam jet and water spray.

An important improvement in the mode of supplying the water necessary for the reaction in the lead chambers is due to H. Sprengel. It consists in forcing the water in the form of fine spray into the chambers by means of a jet of steam, issuing, under a pressure of two atmospheres, from a platinum tube in the center of a jet of water. In this manner 20 kilos of steam change 80 kilos of water into a cloud of fine spray. The advantages are: (1) An economy of heat corresponding to that necessary to vaporize the 80 kilos of water; (2) cooling of the chambers equivalent to the absence of the same amount of heat; and (3) economy of space otherwise occupied by steam and gases at a higher temperature. The increase of production due to this improvement corresponds to an economy of 6½ per cent. in pyrites and 15 per cent. in nitrate of sodium.

Advantages.

Gay Lussac's tower.

Gay Lussac's tower is now in general use, and no essential modifications in its structure have been introduced. A great part of the loss of nitrous vapors, hitherto difficult to explain, is now attributed to the oxidation in this tower of the arsenious oxide—derived from the arsenic, almost invariably present in pyrites—to arsenic oxide at the expense of the oxygen of nitrogen compounds.

De Hemptinne's vitriol chamber.

De Hemptinne has introduced a new modification of the manufacture of sulphuric acid, the essential features of which are a diminution of the extent of the vitriol chambers by filling a single one with perforated vessels of stoneware, over which weak acid constantly trickles, admission of liquid nitric acid, and exclusion of water except between the Gay Lussac tower and the chimney. The sulphurous

acid enters the chamber, after having passed through dust-compartments and surrendered its heat to a system of lead tubes containing acid in process of concentration. Denitration takes place in a drum filled with fragments of earthenware, where the acid is brought in contact with gases drawn from the chamber, and returning thither laden with nitrous vapors. The chief advantages claimed for this system are denitration and concentration of the acid without introducing impurities in the form of the pyrites dust—as in the Glover's tower—while still utilizing the heat of the furnaces; reduction of the cost of the plant of the chambers to about one-seventh, by filling a single chamber with sufficient vessels to supply the necessary surface for the reactions; suppression of the jets of steam hitherto in use; rapidity of production; and concentration by means of superheated steam. With regard to the disposition of the lead chambers, it is well to remark that numerous experiments of late years tend to show that the amount of surface exposed plays a much less important part than has heretofore been supposed. The introduction of masses of coke into the chambers, and other similar devices, have given no practical results. De Hemptinne has as yet given no detailed statistics on the actual results of this method, although twelve years have elapsed since the commencement of his experiments.

Sulphuric acid.

De Hemptinne's vitriol chamber.

Glover's tower.

Glover's tower.

The attention of chemists engaged in sulphuric acid manufacture has been directed during the past few years chiefly to the study of the practical utility of the Glover tower, and valuable monographs on the subject have appeared from Bode, Lunge, Vorster, Hurter, and others.

Monographs on the subject.

The first tower was built on the Tyne by John Glover, in 1859. After experiments with brick and lead structures, he adopted, in 1864, the form now prevalent, a rectangular or rounded tower of lead, possessing a height of 25 to 30 feet, and a horizontal section of 60 to 100 square feet, lined with stone, proof against acid and divided into two parts—the lower 6 feet in height, empty; the remaining and upper part filled with fragments of stone ware, and surmounted by a layer of coke. By 1870 most of the large English establishments were provided with the new apparatus, and in 1871 it was introduced into Germany. Since then it has been adopted so universally that at present none of the large English works, and but few of those on the Continent, are without it. (Kuhlman's works at Lille are a notable exception.)

The invention and construction of the Glover tower.

Its almost universal adoption.

Sulphuric acid.

Purpose of the Glover tower.

As originally proposed by Glover, and as used at present in most cases, the tower serves the double purpose of concentrating the chamber acid and denitrating the acid coming from the Gay Lussac tower. With regard to the first function, experience is unanimous in proclaiming its success.

Concentrating the chamber acid.

It utilizes to the utmost the heat possessed by the gases issuing from the furnaces, suppresses the use of compartments for cooling the sulphurous vapors before entering the lead chambers, concentrates the acid at once to over 60° Baumé, and prevents a loss of acid, the small amount present in the water evaporated being saved in the chambers. Vorster finds that in a tower of the capacity of 81 cubic meters 1,400 kilograms of water are evaporated daily, 550,600 kilograms of H_2SO_4 are formed, and from $3\frac{1}{2}$ to 4 per cent. of the acid passing through the tower is carried over into the chambers.

Action on pyrites containing selenium.

When pyrites containing selenium are burned, it is found that the selenious oxide formed is decomposed in the Glover tower, by the action of the sulphurous oxide, leaving selenium behind—$SeO_2 + 2SO_2 = Se + 2SO_3$.

The use of the tower as a concentrator is practical in all cases, except where it is necessary that the acid should be

Coloring action of organic matter in the coke.

free from the brown color resulting from the presence of organic matter in the coke, as well as free from the impurities caused by the entrance of flue dust.

Denitration of the acid in the tower.

With regard to the value of the tower as a denitrating agent, there is a wide diversity of opinion. Vorster, Hurter, and others claim that, while the acid trickling through the tower is completely denitrated by the hot sulphurous vapors passing through on their way to the chambers, the reaction goes so far that a large percentage of the nitrogen com-

Opinions as to the loss by reduction of the nitrogen compounds.

pounds present are reduced either to the form of monoxide or to nitrogen itself, and thus rendered utterly useless. They attribute further to this reaction the hitherto unexplained loss of the higher oxides of nitrogen in the manufacture. On the other hand, Lunge shows, by very carefully conducted experiments, that a mixture of SO_2 and air, corresponding to the mixture issuing from the pyrites furnaces, denitrates acid from the Gay Lussac tower at a temperature of 200° without formation of nitrogen or its monoxide. In the Glover tower the reaction should be the same; the gases on entering possess a temperature of 300°, but give off heat rapidly to the denitrated acid at the bottom of the tower. They first encounter acid not entirely denitrated in the middle of the tower, where the temperature of the acid is 70° and of the gases 175°. The acid is

chiefly denitrated in the upper portion of the tower, from which the gases enter the chamber with a temperature of 50°. Davis claims that the loss of nitrous compounds is due to the presence of arsenious acid, which is oxidized at their cost in the Gay Lussac tower. Experiment with the Westphalian pyrites, which are free from arsenic, should settle this point. *Sulphuric acid.*

Concentration to 66° *B.*=1.8 *sp. gr.* Concentration to 66° B.

In the methods of concentrating sulphuric acid from 55° B. (1.59 *sp. gr.*) or 60° B. (1.71 *sp. gr.*), the highest degree capable of being attained in leaden vessels under ordinary circumstances, to 66° B. (1.84 *sp. gr.*), the degree required for the strongest acid, very important modifications have been introduced. The aims kept in view have been to replace totally or in part the costly platinum hitherto in use for retorts, to lower the temperature at which the concentration can be accomplished in these substitutes, and to economize fuel. De Hemptinne states that he has successfully solved the problem of completing the concentration in leaden vessels by means of the vacuum. The leaden basins of his apparatus, which contain the acid, fit tightly in iron basins, which protect them from the pressure of the atmosphere and transmit the heat of the furnace. A partial vacuum is obtained by driving the air from the large cylinder in communication with the recipient, by means of steam, which is afterwards condensed by a stream of cold water. Towards the close of the distillation as complete a vacuum as possible is obtained by the use of a Bunsen pump. Although the method has been in use since 1873, details with regard to its successful operation are still wanting, and leading authorities doubt the possibility of obtaining an acid tolerably free from sulphate of lead in this manner. Replacement of the costly platinum apparatus. De Hemptinne's vacuum process. Lead-lined iron vessels. Opinions as to the freedom of the result from sulphate of lead.

Better success has attended the introduction of Faure & Kessler's new concentrator. This apparatus, intended to supersede the old form of platinum stills, consists essentially of a shallow pan of platinum, resting above the free fire and of a capacious cylindrical cover of lead, resting in a channel formed by curving the upper edge of the pan. The cover replaces the upper part of the platinum stills, as well as the adjoined worm, being made with double walls, between which cold water constantly circulates. The weak acid distilled off condenses on the walls of this cover, flows down into the channel referred to, thereby forming a hydraulic joint between the pan and its cover, and is drawn off from Faure & Kessler's concentrator. Platinum pan with leaden cover and worm.

Sulphuric acid.

the outside. The water drawn off at first is conducted directly into the vitriol chambers or into boilers by a tube from the conical summit of the cover. In previous forms of Faure & Kessler's concentrator the furnace with the pan stood in the middle of a small lead chamber, over the outside of which cold water constantly trickled. The chief advantages of this apparatus are diminution of platinum necessary for a certain rate of concentration to one-third of the amount formerly required; avoidance of violent ebullition, on account of the small amount of acid present at any one time in the pan—less than 10 centimeters in depth; an economy of 30 per cent. in fuel; ease of making repairs; smaller proportional loss of platinum. The firm has already supplied 65 concentrators since 1873, of which 7 have been sent to the United States.

Faure & Kessler's concentrator.

Advantages.

The marked advantages and economy resulting from the use of this style of apparatus at once brought about a revolution in the manufacture of platinum stills.

Johnson, Mathey, & Co.'s still.

Johnson, Matthey, & Co., of London, have introduced an oblong, low still, in which the rapidity of evaporation is insured by the use of a fluted or corrugated bottom. The acid passes from the lead pans first into open platinum pans with similarly fluted bottoms, and finally into the retort described. The firm claims likewise to have first introduced the principle of distilling acid in shallow vessels.

Demontis, Quenssen, & Lebrunne's still.

Desmontis, Quenssen, & Lebrunne, of Paris, also supply a still, exceedingly shallow, in which vertical concentric divisions force the entering acid to pass over a tolerably long route before reaching the outlet tube—an arrangement which allows concentrated acid to be continuously drawn off by this tube. Other arrangements allow the acid to pursue a zigzag course from one side of the still to the other, so that the strongest acid is always above that part of the still most exposed to the heat of the furnace.

Liebig's improvement.

Liebig's improvement, by which the still can be turned from time to time, appears to give satisfactory results.

A few comparative statements of results obtained with the various forms of stills will show the present state of the question between the rival merits:

Comparison of the results obtained from various stills.

	Amount of sulphuric acid of *sp. gr.* 1.84.
Old form of still, weight of platinum 32.5 kilos, concentrated in 24 hours	2,800 kilos.
Desmontis & Co., new form, weight of platinum 17.6 kilos.	1,500 kilos.
Desmontis & Co., Liebig's form, weight of platinum 24.34 kilos	4,500 kilos.
Johnson, Matthey, & Co., new form, weight of platinum 20 kilos, cost $5,000	4,000–5,000 kilos.

Sulphuric acid.

	Amount of sulphuric acid of *sp. gr.* 1.84.
Johnson, Matthey, & Co., 2 open pans and 4 lead pans, 37.3 kilos	8,000 kilos.
Faure & Kessier's pan, costing $3,000	2,500 kilos.

Comparison of results from various stills.

By Faure & Kessier's system, with a monthly production of 75,000 kilograms, there is a saving of 13 cents per 100 kilograms of acid in the cost of concentration, as compared with the old system.

On the loss of platinum in the stills.

The loss of platinum in the stills during the concentration has been carefully examined by Scheurer-Kestner. He finds that when nitrogen compounds are absent from the acid, 9½ grams of platinum are dissolved in the concentration of 1,000 kilograms of the monohydrate. The presence of nitrogen compounds causes a still greater loss. The presence of 30 per cent. of iridium in the alloy of which the still is made doubles the resistance. The alloy of platinum, containing 30 per cent. of iridium, is, however, too brittle for practical purposes.

Lichtenberger's iron still.

G. E. Lichtenberger has introduced an iron still for the concentration of sulphuric acid, which, if entirely successful, may solve the question of the platinum vessels in an unexpected manner. It consists of a simple retort of cast iron, provided with a leaden cover and leaden worm. The cover is kept cold, and acts as a condenser, channels on its internal surface conducting the condensed acid to a recipient. The use of this still is based on the fact that while hot acid at 60° B. attacks iron vigorously, with evolution of hydrogen and sulphurous anhydride, this property is lost as soon as the concentration attains 64° B. (1.79 *sp. gr.*). The still is therefore filled, at the start, with a mixture of 60° B. acid and 66° B. acid, possessing the 64° B. concentration. When this amount has been concentrated to 66° B., one-half of it is drawn off, and sufficient 60° acid is added to bring the strength again down to 64°, when the evaporation is resumed. A still 1 meter in diameter and 56 centimeters in depth concentrates in this manner about 1,400 kilograms of acid, in 24 hours, to 66° B.

English glass retorts.

In England glass retorts are used for the greater part of the acid concentrated, although it is difficult to obtain a strength above 65° B. (1.82 *sp. gr.*). For the strongest acid platinum stills are required. The glass retorts are usually 1 meter high and 0.56 meters in diameter, of thin, very evenly blown glass. They rest on sand-baths, and are protected by plates of fire-clay from the direct action of the flame. A common arrangement for providing continuous working is to place them on terraces, in series of threes, connected

Sulphuric acid. with each other by means of syphons. Acid, at a temperature of 150° C., enters the upper one, and, after partial concentration, flows into the second, and then into the third, from which the most strongly concentrated acid is drawn off through a cooler into the carboys.

Purification.

Purification of sulphuric acid.

Removal of arsenic by—

The removal of arsenic present in the product of the great majority of works is an operation usually avoided where it is not absolutely essential to protect the platinum stills. In many establishments sulphureted hydrogen is still used. The technical difficulties standing in the way of its use have led to the adoption lately of other means. One consists in the addition of sodium hyposulphite to the chamber acid of 50° B., the arsenious acid present being precipitated as As_2S_3, and sulphate of sodium remaining dissolved in the acid. By this method the percentage of arsenic is reduced from 0.098 to 0.004.

Sulphureted hydrogen,

Sodium hyposulphite,

A still better method, leaving no salt in solution, is that of Dupasquier, depending on the use of barium sulphide, which yields a precipitate of As_2S_3 and $BaSO_4$.

Barium sulphide.

In his recent report on the manufacture of sulphuric acid in France, M. A. Favre gives an interesting statement of the present cost, in that country, of producing 1,000 kilos of acid at 50° B., or 1.53 specific gravity:

Cost of production of sulphuric acid.

	Francs.
640 kilograms pyrites (35 to 40 per cent. sulphur), 3 francs per 100 kilos	19.20
18 kilograms Chili saltpeter, 38 francs per 100 kilos	6.84
30 kilograms sulphuric acid at 60° B., to decompose the nitrate	1.20
80 kilograms coal, 30 francs per 1,000 kilos	2.40
Labor and breakage	3.26
General expenses and maintenance	5.00
	37.90
Deduct 20 kilograms sodium bisulphate, at 5 francs per 100 kilos	1.00
1,000 kilos sulphuric acid, at 50° B	38.90

Which in our money makes the acid cost about 36 cents per pound.

Fuming sulphuric acid.

Fuming or Nordhausen sulphuric acid.

Until a recent date the manufacture of fuming sulphuric acid has been a monopoly of the famous Stark Works, in Northwestern Bohemia. There it was first manufactured over three centuries ago, and thence the industry was transplanted to Nordhausen and other localities in Germany, in none of which, however, it exists at present. No essential changes have been introduced in the general method of

Nordhausen.

Sulphuric acid.

manufacture since its origin, although within the past fifty years notable economies in fuel, labor, etc., have been effected. The vitriol-slate which occurs in quantities in the neighborhood of Pilsen and Elbogen contains from 12 to 31 per cent. of sulphide of iron. On exposure to moist air for about three years, the sulphide is changed almost completely into ferrous and ferric sulphate. These salts are extracted by lixiviation, the solution evaporated, and the residue calcined, in order to entirely expel the water and change the ferrous sulphate as completely as possibly into ferric sulphate. This calcined mass—the so-called vitriol-stone—when pulverized, is introduced into fire-clay flasks, and subjected to distillation, yielding fuming sulphuric acid, which is collected in recipients, and oxide of iron, which remains in the flasks, constituting the *caput mortuum* of early chemistry.

Nordhausen process.

Stark Works.

In the Stark Works 2,928,000 kilos of vitriol-stone are distilled yearly, yielding 1,720,500 kilos of fuming sulphuric acid and 1,350,000 kilos of oxide of iron, which after a special treatment is delivered into commerce, where it finds a ready sale as pigment. These immense works contain 12 acid distilleries, with 110 furnaces, and annually employ 72,400 retorts or flasks and 40,000 receivers. Sulphuric anhydride is also prepared by this establishment.

Uses of fuming sulphuric acid and sulphuric anhydride.

The use of fuming sulphuric acid, as well as of sulphuric anhydride, which was formerly limited chiefly to the requirements of indigo dyers, has been widely extended since the discovery of ozokerite and the introduction of aniline and anthracine dyes, notable quantities being required, especially in the manufacture of artificial alizarine. This increased demand, as well as the probability of a still more extended use in the future, has naturally led to a study of methods available for the manufacture of this powerful reagent, by means of which it can be freed from the present monopoly, and the dependence on local conditions, such as the possession of large deposits of vitriol-slate, and placed on the same basis of free competition as the other leading products of the great chemical industries.

Processes of manufacture.

For this purpose two processes are now in use. The first is based on the utilization of the bisulphate of sodium obtained in quantities from the sulphuric acid works and from the manufacture of nitric acid. It is a method which has frequently been proposed, and even carried into execution on a small scale. It depends on the fact that when bisulphate of sodium is melted it loses water—

$$2NaHSO_4 = H_2O + Na_2S_2O_7;$$

Sulphuric acid. and when heated to 600° C. it loses sulphuric anhydride—

$$Na_2S_2O_7 = SO_3 + Na_2SO_4.$$

Fuming sulphuric acid. For two years past considerable quantities of sulphuric anhydride and fuming sulphuric acid have been manufactured in both France and England by this method; and it is stated that the process is continuous, sulphuric acid being added to the residual sulphate of sodium to regenerate the bisulphate. The manufacture is still, however, in the experimental stage, and has not overcome certain technical difficulties facing the production on a large scale.

Winkler's process. The second process is of an exceedingly original, ingenious, and elegant character, and was proposed in 1875 by Professor Winkler, of Freiberg, who generously offered it to the industrial world free from all patent restrictions. This process is based on two simple reactions: the union of sulphurous anhydride and oxygen to form sulphuric anhydride, when passing at not too high a temperature over certain so-called catalytic substances; and the nearly complete decomposition at a high temperature of sulphuric acid into water, oxygen, and sulphurous anhydride—

$$SO_2 + O = SO_3 \; : \; H_2SO_4 = H_2O + O + SO_2.$$

Description of process. The operation consists, firstly, in passing the vapors of concentrated sulphuric acid through an iron tube, lined internally and externally with fire-clay and filled with fragments of porcelain, which are kept a bright red heat. The decomposition here is almost complete, and the resultant gases are conducted through a system of lead tubes, which serve for the condensation of most of the aqueous vapor present; and, finally, to remove the last traces of water, the gases are passed through a scrubber filled with pumice-stone, over which concentrated sulphuric acid constantly trickles. The mixture of oxygen and sulphurous anhydride is next conducted through tubes of fire-clay heated to dull redness, in which are contained the contact substances necessary to induce the union of the gases. For this purpose finely divided platinum is best adapted, and the most practicable form is found to be the so-called platinum asbestus, prepared by soaking very soft asbestus in a concentrated solution of chloride of platinum, then dipping it into a solution of chloride of ammonium, and heating it to a glow, after first drying the mass. Under the most favorable circumstances thus far, about eight-tenths of the sulphurous anhydride passed through the apparatus is oxidized to sulphuric anhydride, which is condensed in lead chambers or

conducted into sulphuric acid to form Nordhausen or fuming sulphuric acid. *Sulphuric acid.*

The principal difficulties at the commencement of the fabrication are the arrangements of satisfactory retorts for the distillation of the sulphuric acid and the avoidance of a loss of platinum from the presence of arsenic in the acid used. These obstacles appear to have been satisfactorily overcome, as the process is in regular operation in one English and three German establishments. In consequence of its introduction, Nordhausen acid is now sold at one-third of its former price. The platinum apparatus necessary for the fabrication is advertised by Johnson, Matthey, & Co., of London, at $10,000. Fuming sulphuric acid. Winkler's process. Cost of necessary platinum apparatus.

A method just introduced by Walters in Germany is based on the action of sulphate of magnesium on dehydrated bisulphate of sodium—$Na_2SO_4+SO_3$. At a temperature sufficiently elevated to liquify the latter, the double sulphate of soda and magnesia is formed, and the sulphuric anhydride thereby set free is distilled over. The great advantage of this method is the low temperature at which the anhydride is produced, a circumstance allowing an easy choice of material for the necessary apparatus. The residual double sulphate is dissolved, and the two salts separated by crystallization, to be used again for the same purpose, the soda salt receiving, naturally, an additional equivalent of sulphuric acid after each operation. Walters' process.

Sulphuric anhydride is sent into commerce inclosed in sheet-iron or tin-plate boxes, it having no action on the metals in the absence of moisture.

Sulphurous and hydrosulphurous acids.

Sulphurous and hydrosulphurous acids.

An important new application of sulphurous anhydride is for the manufacture of artificial ice by Pictet's method. The cheapness of the gas and its easy compressibility render it eminently adapted for this purpose. Thousands of hundredweights of ice were manufactured during the Exhibition in a special building in the grounds, erected by the Pictet Ice Company. Use in the Pictet Ice process.

Sulphurous acid is now required extensively in dyeing. Bisulphite of lime has now entirely superseded sulphur as an anti-ferment in the wine and beer making industries. In the latter manufacture it, together with salicylic acid, is the sole means now used for arresting the fermentation at the proper moment, and to prevent any subsequent action. In dyeing. As an anti-ferment.

Hydrosulphurous acid, and especially its sodium salt, discovered by Schützenberger in 1873, rank among the most Schützenberger.

Sulphuric acid.

powerful reducing agents now at the command of the technical chemist. The sodium salt—$NaHSO_2$—in aqueous solution, forms an excellent substitute for ferrous sulphate in the indigo vat, especially for woolen goods. For ordinary dyeing, it increased the ease and rapidity of the operation, while insuring purer shades; and in printing it causes a saving of 50 per cent. of the indigo used, while permitting at the same time the printing of aniline and other dyes, as well as offering other facilities. The solution of sodium hydrosulphite is prepared by adding one part of zinc powder to from 10 to 15 parts of a solution of sodium bisulphite, making 24° B., and stirring until the odor of sulphurous acid ceases to be given off. The same solution is also used for bleaching woolens. Since the introduction of this reagent a new impetus has been given to the woolen industry in certain districts of Belgium and France.

Use of the sodium salt of hydrosulphurous acid in dyeing.

Nitric acid.

NITRIC ACID AND NITRATES.

Manufacture of nitric acid.

This acid is still manufactured exclusively from sodium nitrate (Chili saltpeter), by decomposition with sulphuric acid, none of the proposed substitutes offering a more satisfactory method. The most important of these proposed improvements are the decompositions of sodium nitrate by manganese chloride (Kuhlman), by alumina (Wagner), and by calcium carbonate and steam (Walz). Noteworthy advances in the technical arrangements are the following: Introduction of horizontal cast-iron cylinders in place of the former elliptical retorts for decomposition, permitting economy in fuel and greater ease in conducting the operation; use of Cleve's changeable cock, permitting the separation of the colorless acid from the fuming acid during the reaction; substitution of glass tubes for the former stone-ware heads of the retorts, allowing a constant control of the reaction in the retorts; introduction of cylindrical recipients; absorption of the vapors issuing from the last recipient by sulphuric acid in a coke scrubber, forming nitrous acid similar to that obtained in the Gay Lussac tower; passage of the acid vapors through a glass condenser. This last is a most important improvement. One of the chief difficulties hitherto in the manufacture of nitric acid has been the brittle character of the stone-ware recipients when exposed to the rapid changes of temperature necessary in economical and continuous work. In England this annoyance is avoided by letting the acid vapors pass through a worm of stone

Made exclusively from Chili saltpeter, (nitrate of soda) by decomposition with sulphuric acid.

Substitute processes of Kuhlman, Wagner, and Walz.

Important technical improvements in the apparatus.

Fragility of the stone-ware recipients,

and the worm.

ware. The unavoidable fragility of the latter, however, entails frequent loss. Goebel, in Belgium, has replaced the worm by a suitable glass tube, arranged much as the familiar condensers of the laboratory, and kept cool with a constant stream of water. By this simple contrivance he lessens the number of the recipients to a third of the former number, entirely prevents their breakage, and increases the production by 20 per cent.

Nitric acid.

Glass worm.

The residual sodium sulphate from the decomposition of sodium nitrate is now profitably used in the manufacture of soda crystals, as well as of Nordhausen sulphuric acid.

Use of the residual sodium sulphate.

Julian, in France, has patented a method of preparing nitric acid by passing the electric spark through strongly compressed air.

Nitrate of soda (soda saltpeter).

Nitrate of soda.

The nitrate of sodium, which now forms the great source of nitric compounds, is derived almost entirely from the western coast of South America. The deposits are found in a territory about 2,400 miles in length, extending through Peru, Bolivia, and Chili, which is supposed to have been the bed of an inland sea, and to have since been elevated by volcanic agency. The deposits are found in a marly earth, from three to thirty feet below the surface, and contain usually from 48 to 55 per cent. of nitrate of sodium, 35 to 40 per cent. of chloride of sodium, and 10 to 12 per cent. of insoluble matter. They are loosened by blasting, and the pulverized mineral undergoes a series of lixiviations. The old method of boiling the mass with water is now superseded by extraction at a lower temperature, a change followed by an increase of 30 per cent. in the yield of nitrate. The nitrate crystallizing out of the solution, after the deposition of the chloride of sodium, contains 95 or 96 per cent. of nitrate of sodium. In the methods of transport and extraction there is still much room for improvement.

The deposits of the west coast of South America.

Character of deposits.

Mode of working.

Improved process.

Peru possesses over one hundred and thirty nitrate works, producing annually about 300,000,000 kilograms, over half of which is absorbed by England. At present all these works are in the hands of the government, which has purchased them for $17,500,000 in 1877, and it intends to make a monopoly of the manufacture.

Nitrate works of Peru.

During the past year very extensive deposits have been found in the province of Atacama, Chili, containing 30 per cent. of nitrate of sodium. The production of nitrate in Bolivia has been greatly increased since the existence of the

Chilian deposits at Atacama.

Works in Bolivia.

Nitric acid.

government monopoly in Peru, the port of Antofogasta alone exporting 1,180,000 kilograms monthly.

Nitrate of potash.

Nitrate of potash or saltpeter.

Process by double decomposition of potassium salts and nitrate of sodium.

The manufacture of this salt from double decomposition of commercial potassium salts and nitrate of sodium has now attained a high degree of perfection, and forms at present the main source of this important compound. But comparatively small quantities of saltpeter are now exported from India and other tropical countries, and the so-called saltpeter beds are scarcely to be found outside of Sweden, where the government still requires an annual contribution from each landholder. The increase in the price of nitrate of sodium growing out of the Peruvian monopoly may possibly revive some of the discarded methods for forming saltpeter. In the great Austrian works at Simmering, manufacturing 2,500,000 kilograms annually, chloride of potassium from Kalusz is used, on account of its freedom from magnesium salts. In the other leading European works the Stassfurth salt is used. In the three German works now in operation 20,000,000 kilograms are produced annually.

Probable effects of Peruvian monopoly.

Production of Austrian works at Simmering.

Production of German works.

Schmidt's process.

Schmidt, in Denmark, obtains saltpeter by adding nitrate of sodium to the mother liquors remaining after the separation of the iodine and magnesia from the solution yielded by the lixiviation of kelp ash. By a new French process the conversion of the nitrate of sodium into the potassium salt is effected by inclosing the solution in an autoclave, provided with a stirring apparatus, and exposing it to the action of steam at a pressure of six atmospheres.

New French process.

Very impure saltpeter is brought from Peru, obtained from the residual liquors after the crystallization of the nitrate of sodium.

Considerable quantities of niter are now manufactured in Belgium from Chili saltpeter by decomposing it with carbonate of potassium, obtained from the ashes of the beet-root sugar manufactories. The product of this industry is very pure, and it is sold at a low price.

Decomposition with carbonate of potassium obtained from the ashes of the waste of the beet-root sugar process.

During the recent Russo-Turkish war large quantities of saltpeter were exported from America to Europe.

Potassium salts.

POTASSIUM SALTS.

Deposits of potassium salts at Kalusz and Stassfurth.

The rapid development of the enormous deposits of potassium salts at Kalusz, in the Carpathians, and at Stassfurth, in Central Germany, has caused the usual processes for obtaining these compounds to descend to a somewhat

subordinate position. The use of pearlash is become more and more limited. Thus the export of pearlash from Lower Canada to Europe has diminished during the past twenty-five years from 7,500,000 kilos to 5,000,000 kilos. *Potassium salts.*

The extraction of the potassium salts from the *suint* of raw wool, a practice introduced in 1859, grew to be an important industry in a few years, a full and exhaustive description of which was given by A. W. Hofmann in his report on the Chemical Industries as shown at the Universal Exhibition held in London in 1862. This industry originated in France—growing out of the researches chiefly of Vauquelin, in 1803, and of Chevreul, in 1828—where it still flourishes, notwithstanding the unequal contest with the Stassfurth minerals. It is also carried on in Germany and in Hungary, where, by the process of exhaustive lixiviation now practiced, a yield of over 30 kilos of crude potash, containing 80 per cent. of potassium carbonate, from 1,000 kilos of wool is obtained. Potash extracted from *suint* is said to contain no soda. Potash from suint. Hofman's report: London Exhibition, 1862.

The combined effect of the Stassfurth deposits and the South American supplies of iodine have exerted a depressing influence on the extraction of salts from sea-weed ashes, especially in France. A most ingenious process has been introduced by Herland, which, by increasing the yield of potash and of iodine, will probably enable this industry to maintain its existence. Instead of being burned, as hitherto, the freshly-gathered kelp, packed in iron baskets, is immersed in lime baths—containing 50 kilos of caustic lime to the cubic meter of water—and allowing the salts to be extracted by the process of osmosis. By diffusion through the walls of the cells of the vegetable the salts of the plants go into solution and are replaced by lime. The plants are are used for fertilizers, where potash salts are not required; and the solutions, on being treated as usual, yield three times the amount of potash and iodine obtained by former processes. The extraction of chloride of potassium from the mother-waters of the salt gardens in France had assumed large proportions at the time of the discovery of the deposits in Germany. Since that time Merle has introduced such important modifications into the methods practiced, that now it is possible to produce chloride of potassium at a price even below that of the German or Austrian product. Causes of depression of the processes of extracting salt from sea-weed. Herland's process. Steeping the kelp in caustic lime solution. Extraction of chloride of potassium from the mother-waters of the salt gardens.

The most important and the most recent of these improvements consists in a simple method for obtaining anhydrous sodium sulphate (thenardite) from crystallized glauber salt ($Na_2SO_4 + 10H_2O$). In the concentration of the mother- Merle's improved processes.

Potassium salts. waters necessary for the separation of the chloride of potassium, a precipitate of crystallized sodium sulphate, ten times the weight of the potassium salt, is obtained as a lye product. On account of the cost and technical difficulties connected with the reduction of this salt to the anhydrous state by the action of heat, it was practically of but little value. The new method of utilizing this salt is based on the fact that when it is liquified in its water of crystallization at 33° C., and there is added to the solution 20 to 22 per cent. of common salt, or, better still, a mixture of magnesium sulphate and sodium chloride—precipitated at one stage of the operation—the entire quantity of sodium sulphate present is precipitated as a fine powder, in a high state of purity. In this form the sulphate is prized by glass-makers. This advantageous disposition of the most important lye product in the operation enables the chloride of potassium to be produced at a price allowing successful competition with the Stassfurth salt, even outside of France. As, however, the amount of chloride of potassium obtained in this way is proportionate to the production of salt (1 to 33), this industry must necessarily remain somewhat limited.

Merle's process.

Manufacture of potash from *vinasse.*

The manufacture of potash from the *vinasse* left after the distillation of fermented beet-root molasses has formed for the past forty years an important branch of industry in France, Germany, and Belgium. It was estimated, in 1874, that no less than 12,000,000 kilos of potash were derived from this source alone. This quantity is less now, on account of the increased practice of extracting the sugar from the molasses by osmosis or elution. This industry has assumed a new interest since the introduction in France of Vincent's method for the utilization of the products resulting from the carbonization of *vinasse.* The calcination in reverberatory furnaces is replaced by distillation in retorts, a process yielding an extremely porous residue, easily lixiviated, and allowing the ammonium salts, trimethylamine salts, and methylic alcohol in the distillate to be saved.

Vincent's process.

Calcination substituted by distillation.

Potassium salts from Stassfurth minerals.

Potassium salts from Stassfurth minerals.

The production of potassium salts at Stassfurth and the neighboring district is steadily increasing. In 1876 the mines delivered 547,000,000 kilos of potassium salts, and at present the yield is about 2,000,000 kilos daily, an amount corresponding to about 500,000 kilos of chloride of potassium daily. The system of boring introduced by Douglas is now in successful operation. In 1877 a boring made by a company south of Stassfurth reached a rich stratum of

Product of the mines.

Boring process of Douglas.

potassium salts, 20 meters thick, at a depth of 240 meters from the surface, below various deposits of gypsum and sandstone. But few changes have been made in the treatment of the salts. Brünner has brought into use a new method for preparing potassium sulphate from chloride of potassium and kisserite ($MgSO_4+H_2O$) or kainite (potassium sulphate and magnesia), which consists in adding alcohol to a solution of the salts. This causes an instant precipitation of potassium sulphate, with small quantities of chloride of potassium. After evaporation of the alcohol, concentration to 1.26 *sp. gr.* causes a separation of pure chloride of potassium, and further concentration a precipitation of pure carnallite ($KClMgCl_2+6H_2O$). The most notable improvement in this industry is Pfeiffer's ingenious utilization of the residues accumulating in the preparation of chloride of potassium. The average composition of the Stassfurth deposits is:

Potassium salts.

Brünner's method.

Pfeiffer's mode of utilizing residue.

Composition of the Stassfurth mineral.

	Per cent.
Carnallite($KClMgCl_2+6H_2O$	58.5
Rock salt ($NaCl$)	21.
Kisserite ($MgSO_4+H_2O$)	15.
Anhydrite, boracite, tachyhydrite, sand, etc	5.5

After the extraction of the chloride of potassium, there remains a residue of about 30 per cent., consisting of:

Residue after extraction of the chloride of potassium.

	Per cent.
KCl	5.25
$NaCl$	47.
$MgCl_2$	3.85
$MgSO_4$	29.25
H_2O	6.50
Insoluble	8.15

The residues have frequently been treated in winter for the extraction of glauber salt, but, as this is scarcely remunerative, enormous quantities of the above mixture of salts have accumulated about the various works. Pfeiffer finds that this residue serves admirably, in its actual form, as a source of alkalies for common glass. Large quantities have already been introduced into bottle glassworks. In view of the great extent of these residues, it will be found profitable to introduce at Stassfurth, in addition, the new French method described above for the separation of anhydrous sulphate of sodium from the mother-waters.

Use of the residue as a source of alkalies for glass works.

Potassium carbonate is now manufactured extensively from the chloride by De Gonsillier's modification of the ammonia process, viz, the use of a very dilute alcohol—35 per cent. In this menstruum, chloride of potassium, chloride of ammonium, ammonia, and carbonic acid are easily soluble, while potassium carbonate is almost entirely insoluble.

De Gonsillier's modification of the ammonia process.

Potassium salts.

Siemen's apparatus.

An apparatus, working continuously, has been devised by W. Siemens, in which the loss of alcohol does not amount to more than 0.5 per cent. of the quantity in use for each 100 kilos of potassium carbonate.

Soda industry.

THE SODA INDUSTRY.

Noteworthy advances have been made in this industry during the past few years. As the most important fact revealed by the Exposition of 1878 in this connection, should be mentioned the complete vindication of the ability of the new ammonia-soda process to compete with the Leblanc process, after having satisfactorily sustained the test of a twelve years' trial. The realization of this result has, however, called forth an unusual amount of inventive effort among those interested in the maintenance of the old system, especially in England, which has resulted in the introduction of numerous new mechanical contrivances for nearly all the processes hitherto in vogue, at once lessening the past dependence on skilled labor, effecting more thoroughly the chemical decompositions underlying the process, and causing considerable economy in material and fuel. At the same time Hargreaves's ingenious process, regarded by many as the method of the future, slowly attains a degree of perfection which may possibly enable it shortly to prove the most important factor in finally settling the status of the ammonia-soda manufacture.

Success of the new ammonia-soda process.

Hargreaves.

England still continues to be the chief source of alkali, exporting annually about 275,000,000 kilos to supply the wants of other countries. No other country has as yet raised its manufacture to a quantity equaling its consumption, not even France, with her apparently unlimited sources of raw material and advantageous position. It is in fact almost impossible for any country to successfully compete with England in this branch, on account of the rare combination of circumstances favoring the British manufacturer. These consist chiefly of the cheapness of all raw material required and the enormous interests vested in the manufacture, which admit of the construction of expensive apparatus, calculated for a production far above that attempted in the great majority of Continental works. Thus, three of the leading establishments on the Tyne manufacture much more than the whole twenty works in Germany. It is to be remarked, however, that this great economical triumph is not combined with a corresponding purity of product, and in this respect the products of the French and German works are decidedly superior. This overwhelming superi-

England the chief source of alkali.

Combination of advantages favoring Britain.

Product less pure than those of France and Germany.

ority of England is chiefly felt in Germany, where, despite the perfection of the chemical management, one-third of the works have been closed during the past few years, unable to contend against the difficulties facing the soda industry in that empire. *Soda industry.*

Extensive deposits of natural soda have been discovered in Wyoming Territory, covering nearly 1,000 acres. It is claimed that this natural salt is as pure as that occurring in commerce, and that the amount is sufficient to supply the world's demands for centuries to come. The realization of these expectations may possibly change entirely the future of this extensive industry. A thorough scientific investigation of these deposits is, however, still wanting. Discovery of deposits of natural soda in Wyoming.

The amount of soda obtained from kelp is now comparatively unimportant.

The manufacture of soda from the cryolite of Greenland is now confined to this country, with the exception of a single establishment in Denmark. About 8,000,000 kilos of cryolite are required annually for this branch, of which 6,000,000 come to America. Soda from cryolite.

Large amounts of sulphate of sodium are now obtained from the mother-liquors remaining after the extraction of chloride of potassium at Stassfurth, or those used for the extraction of the same salt in the French salt gardens by the methods alluded to in connection with potassium salts, as well as from the mother-liquors after the extraction of copper from the residues of the pyrites burners. Sulphate of sodium from the mother-liquors at Stassfurth.

PRODUCTION OF SULPHATE OF SODA AND HYDROCHLORIC ACID. Sulphate of soda and hydrochloric acid.

The use of the time-honored "decomposer" and "roaster" for the changing of chloride of sodium into sulphate of soda, with the attendant laborious manipulation, is now being superseded by more rationally constructed furnaces. Jones & Walsh have introduced, within the past four years, a furnace which is now in operation in over a dozen English works, although scarcely out of the experimental period. Jones & Walsh furnace.

It consists of a large, comparatively shallow iron pan (exposed to a free coke fire), in which the entire reaction takes place and is completed. An axle passes down through the masonry above the pan to its center, and is provided with a system of projecting branches terminating in iron shovels. By the motion of the axle, the entire contents of the pan are thus kept in constant agitation. A slight change of the disposition effects likewise the discharge by the same agency. A hopper above, with a conical valve, Description.

Soda industry.

permits the introduction of the entire charge of salt at once. About four-fifths of the necessary amount of sulphuric acid is admitted by two or more leaden tubes, and

Jones & Walsh process.

the machinery is set in motion. The evolution of hydrochloric acid is extremely regular, and there is no foaming

Chloride of sodium into sulphate of soda.

over of the mass. After the lapse of fifteen minutes, a small quantity sufficient for a test is taken out, and then the exact amount of acid required to complete the reaction or decomposition is added. By this method a saving of 5 per cent. in sulphuric acid is effected, and the temperature necessary for the reaction is reduced from 650° C. to 425° C. The chief difficulty not yet fairly overcome is the decomposition of the last portions of the salt. The cost of this furnace, with the necessary steam-engine, is about $2,000.

Cammack & Walker's decomposing furnace.

A recent improvement is a revolving pan with a stationary stirrer. In a decomposing furnace invented by Cammack & Walker the process is continuous. The mixture of salt and sulphuric acid, in equivalent proportions, enters at one end of a long, horizontal, cylindrical rotating furnace, and issues at the opposite end in the form of sulphate of sodium. The technical difficulties attending the removal of the sulphate have not yet been entirely overcome.

While Jones & Walsh aim at the economical transformation of salt into sulphate of sodium by means of sulphuric

Hargreaves & Robinson's sulphate of soda process.

acid, Hargreaves & Robinson, by a method patented in 1870, seek to introduce a much more radical change, viz, to leave out the major part of the processes now involved in the manufacture of sulphuric acid, and effect the formation of sulphate by bringing the gases usually conducted

Bringing the sulphur gases produced by roasting pyrites in contact with chloride of sodium.

from the pyrites burners to the lead chambers in company with steam, directly into contact with chloride of sodium at the proper temperature. The reaction—

$$2NaCl+SO_2+O+H_2O=Na_2SO_4+2HCl—$$

is, theoretically, a vastly simpler process than that at present involving the construction of vitriol chambers, the consumption of nitrogen compounds, and the concentration of the resultant sulphuric acid, as well as the incomplete action of the best decomposers. So far as the chemistry of the reaction is concerned, the experimental period has been satisfactorily passed, and for several years the inventor's efforts have been directed to the solution of the numerous mechanical and thermal problems on which the success of a new method is so dependent.

Process is in use in England.

At present the method is in satisfactory operation in at least three large English establishments, and on trial by

Soda industry.

several others. In these works, where all the chief technical difficulties have been overcome, it must be confessed that success demands the incessant watchfulness of a scientific man, and has been attained at no slight financial outlay. Thus, Stevenson & Co. have expended over $150,000 in introducing the new process into their works.

Hargreaves & Robinson's soda process.

Description of the process.

The process, as now in operation, is essentially as follows: Both rock and brine salt are adapted for the manufacture. In either case the salt is finely powdered, then slightly moistened, and pressed into small uniform cakes about 1½ inches in diameter, which are thoroughly dried.* These dried and porous cakes are next introduced into cast-iron cylinders, where they remain without further manipulation until changed into sulphate. The cylinders, 12 feet high and 15 feet in diameter, are placed together in a battery of never less than eight, and in one instance as many as twenty. Experience shows that the proportionate consumption of coal decreases, and the production of sulphate in the cylinders increases, in a certain ratio to the increase in the number of cylinders. Each cylinder contains about 40,000 kilos of sulphate at the end of the reaction. The cylinders are so united with each other that gas entering at one end of the battery has to pass through the entire length of each cylinder before issuing from the other end of the series. The arrangement of a battery to allow of the individual cylinders being heated in all parts equally, and to maintain the necessary temperature—450° C., a dull-red heat—for fourteen to twenty days, the time required for the completion of the reaction, without overpassing the amount of fuel required in the old method, has presented a serious problem for solution. Hargreaves has overcome the difficulties so ably, however, that by taking advantage of the heat resulting from the reaction—of itself theoretically more than sufficient to supply all the heat needed—and of the heat of the gases issuing from the pyrites burners, the consumption of coal for the single purpose of heating the cylin-

The heat resulting from the reaction theoretically more than sufficient.

* An excellent salt for this purpose is obtained by the lately introduced method of Pohl for the concentration of brines, in which the flame is conducted between the bottom of one evaporator and the surface of the brine in a second evaporater immediately below the first. By this method the salt in the lower pan is separated in a finely divided state, and, although blackened somewhat by falling soot, serves admirably for the new sulphate process. The reduction of the amount of fuel necessary to evaporate a certain quantity to one-third of the amount hitherto required, as effected by Pohl's new method, may have an important bearing on the future of Hargraves's process, as Pohl's salt is badly adapted for ordinary sulphate manufacture on account of its fine state of division.

Pohl's method for the concentration of brines.

Soda industry.

ders is reduced to 50 kilos, or 5 per cent., per 1,000 kilos of sulphate in a battery of twenty cylinders. To this amount must be added that necessary for the preparation of the chloride of sodium and for the supply of steam, bringing up the total percentage to about 25 per cent., or 250 kilos, of coal per 1,000 kilos of sulphate, a result in all respects satisfactory as compared with the amount demanded in the formation of sulphate by the usual methods. The current of sulphurous anhydride, air, and superheated steam enters the cylinder in which the reaction is nearest completion, and passes through cylinders containing less and less of sulphate, until the mixture of gases and vapor is deprived of all or nearly all sulphurous anhydride, and it reaches the last cylinder, containing salt scarcely attacked, and issues from thence ladened with hydrochloric acid to the condensing towers. About 2 per cent. of the sulphurous acid is lost—a quantity scarcely worthy of consideration in comparison with the losses in sulphuric acid manufacture and the old sulphate furnace. When the contents of the cylinder nearest the kilns have been entirely transformed into sulphate, an ingenious arrangement permits the switching out of that cylinder from the circuit, to be emptied, refilled with salt, and replaced in the circuit as the last member of the series. The sulphate produced contains often over 99 per cent. of sulphate of soda. The inventors are constantly improving the mechanical arrangements of the apparatus.

Hargreaves & Robinson's soda process.

Expenditure of coal per 1,000 kilos sulphate.

Refilling the cylinders and reversing the direction of the gases and vapor.

The sulphate 99 per cent. pure.

Advantages of the system.

The chief advantages of the system, as now perfected, are, (1) economy resulting from the suppression of the manufacture of sulphuric acid; (2) a much purer sulphate than that hitherto obtained; (3) independence of skilled labor; (4) absolute freedom from escapes of hydrochloric acid during the operation; (5) regular development and easy condensation of the hydrochloric acid; and (6) small loss of sulphur. The principal objections are the great expense of the plant, increase of unskilled manual labor, and frequent increase in consumption of coal. At its present stage of development it is extremely probable that after a few years, with their attendant capital of accumulated experience, this new process will have conquered a permanent place in the alkali industry.

Jones & Walsh process for condensing the hydrochloric acid.

In the condensation of the hydrochloric acid evolved in the preparation of sulphate, a valuable improvement is due to Jones & Walsh, the inventors of the furnace described above. It consists in passing the hot gases issuing from the furnace through a stone trough, in the cover of which are numerous openings, permitting the entrance of jets of fine

spray. The effect of this fine shower-bath on the passing gases is to cool them off and free them from the smoke and particles of dust conveyed from the furnace. The exposure to the bath is too short to allow of any great absorption of hydrochloric acid, while in consequence of its cooling effect the absorption in the regular coke tower is very perfect, and the acid condensed there is of good quality. The arrangement is naturally intended chiefly for furnaces where the flame comes in direct contact with the sulphate. The condensation of hydrochloric acid in French works is usually accomplished very thoroughly by passing the gas through a system of Woulff's bottles.

Jones & Walsh process for condensing hydrochloric acid.

Conversion of sulphate into crude soda by Leblanc's process.

Conversion of sulphate into crude soda by Leblanc's process.

For this purpose the use of revolving furnaces is becoming more general in England, although but little progress has been made in this direction on the Continent. An innovation of great importance has been introduced by Mactear in the process, which secures considerable economy in the various steps of the operation. Hitherto it has been usual to add to 100 parts of sulphate 90 to 125 parts of chalk, instead of the 70 parts theoretically required. This excess has been regarded as necessary in order to prevent the formation of hard compact masses of ball-soda, practically insoluble in water, which ensues when merely the exact equivalent of chalk is added. Mactear overcomes this difficulty in the following manner: The mixture of small coal, sulphate of sodium, and the equivalent quantity of limestone is introduced into the revolving furnace invented by Elliott & Russel and improved by Mactear. A slow motion is maintained until the fusion is complete. A small quantity of caustic lime, in coarsely pulverized fragments, is then added, and the furnace is kept in motion until the lime is evenly distributed throughout the mass, and is then rapidly emptied. When the crude soda thus prepared is brought in contact with water, the mechanical action incident to the slaking of the fragments of lime renders the entire mass so porous that its lixiviation is accomplished with the greatest ease. The advantages resulting from this simple change are manifold. The productive capacity of the furnaces is increased from 50 to 70 per cent., both coal and time being saved; the decomposition of the sulphate is more complete; the weight of the entire mass is diminished by 20 per cent., thereby lessening the expense of handling and the amount of soda retained by the residues; there is a general saving of from $1.25 to $2.50 on the ton of soda ash (48

Mactear's improvement on the Elliott & Russel revolving furnace.

Description of the process of working.

Advantages.

Soda industry.

per cent.); the regeneration of sulphur from the soda waste is furthered—the success of this process depending on the

Mactear's improved process.

concentration of the lyes and the absence of carbonate of lime; finally, the soda obtained is as pure as that resulting from the ammonia process—a fact of the first importance for the latter industry, in view of its chief claim, viz, the production of an almost pure product. The only objection brought against the new method is the increased percentage of sulphide of sodium in the crude soda obtained.

Nature of the reactions.

The reaction taking place in the decomposition of sulphate of sodium has been carefully studied by Mactear. He finds that the following reactions occur according to the temperature:

Above a red heat—

$$Na_2SO_4+4C=Na_2S+4CO.$$

At a dull red heat—620°–700° C.—

$$3Na_2SO_4+6C=Na_2CO_3+Na_2S_2+Na_2S+4CO_2+CO.$$

Formation of sulpho-cyanide and ferro-cyanide of sodium.

The formation of considerable quantities of sulpho-cyanide and ferro-cyanide of sodium in the soda process has been observed. Works producing daily 15,000 kilos of crude soda would produce annually about 6,500 kilos of ferro-cyanide and 3,250 kilos of sulpho-cyanide of sodium.

Presence of cyanides in crude sodium.

The presence of cyanides in crude soda has often been remarked. Pechiney has introduced a method to prevent their formation, which consists simply in the addition, at the end of the usual decomposition, of a small additional quantity of sulphate of sodium sufficient to oxidize the cyanides present. Chemists are not yet united on the source of the nitrogen or the reaction to which the cyanides owe their formation.

Query: as to the sources of the nitrogen.

Hargreaves & Robinson's process.

Hargreaves & Robinson propose a fusion of the sulphate with coal and oxide of iron (or manganese or zinc) in large crucibles with perforated bottoms. The crude soda flows out through the openings, and the residual sulphides are oxidized by exposure to moist air. This process, first pointed out as early as 1775 by Malherbe, unsuccessfully tried by Alban, was thought to be perfected in 1854 by E. Kopp and Stromeyer, who fused the materials in the usual soda furnace, where the conversion takes place as follows:

Nature of the conversion.

$$2Fe_2O_3+3Na_2SO_4+16C=Fe_4Na_6S_3+14CO+2CO_2.$$

This crude mass is exposed to air, water, and carbonic acid, which convert the sulphuret of sodium and iron into carbonate of sodium and a double sulphide still containing

sodium, which, by roasting, is converted into oxide of iron, sulphate of sodium, and sulphurous anhydride: *Soda industry.*

$$Fe_4Na_6S_3+2O+2CO_2=2Na_2CO_3+Fe_4Na_2S_3;$$
$$Fe_4Na_2S_3+14O=2Fe_2O_3+Na_2SO_4+2SO_2.$$

Hargreaves & Robinson's process.

This method was abandoned after it was found to be unable to successfully compete with Leblanc's process. This process, so admirable from a theoretical point of view, is defective in one essential respect, which is that it entails a considerable loss of sulphur, which escapes in the course of the operation in the form of sulphureted hydrogen.

Unable to compete with Leblanc's process.

Defects.

The evaporation of the soda lye is usually effected in England by passing over it the flame from the crude soda furnace. In Germany it is not customary to utilize the flame in this way, on account of the deposition of impurities in the soda. In France and Germany it is now usual to accomplish the crystallization in comparatively small reservoirs—a decided saving in time having been found to result from their use.

Evaporation of the soda lye.

In England.

In France and Germany.

Thelen has introduced for the purpose of evaporation a series of pans consisting of long half-cylinders. By the continuous movement of an axle—corresponding to the axis of the cylinder—to which inclined rakes are attached, the salt gathering on the bottom during the evaporation is gradually pushed toward one end, where a shovel, continuously working in a circle, accomplishes its removal from the pan.

Thelen's plan.

For the process of calcination Mactear has introduced a revolving furnace which dispenses with the exhausting manual labor hitherto necessary for this operation. It calcines weekly 100,000 kilos of soda, an amount heretofore dependent on the work of twelve skilled operatives. Its use is said to result in a saving of 60 per cent. in labor and 30 per cent. in fuel as compared with the old fixed furnace.

Mactear's revolving calcining furnace.

Regeneration of sulphur from soda waste.

Regeneration of sulphur from soda waste.

The method for regenerating the sulphur contained in the residues from the lixiviation of ball-soda are now so perfect, and are being so widely extended, that they afford one of the most striking examples in modern technical chemistry of the utilization of a waste product loading the air with noxious gases and long considered as worthless.

With the present perfection of the processes, the greater part of the sulphur in the pyrites used in the manufacture of acid for the alkali industry finally enters commerce in a pure form, after having passed from the form of sulphide of

Nearly perfect saving of the sulphur in a pure form.

Soda industry.

Regeneration of sulphur from soda waste.

iron successively through those of sulphurous anhydride, sulphuric acid, sulphate of sodium, sulphide of calcium, and polysulphides or hyposulphite of calcium.

The following methods of regeneration are now in vogue:

Mond's method.

Mond's method.

The residues are oxidized by the passage of a current of air through the mass. When the oxidation is so far advanced that the lyes contain 1 molecule of hyposulphite to 2 molecules of sulphide, the sulphur is precipitated in open vats by the addition of hydrochloric acid—

$$2CaS+CaS_2O_3+6HCl=3CaCl_2+4S+3H_2O.$$

Schaffner's method.

Schaffner's method.

Description of the process.

The air is allowed to act for several weeks upon the soda waste piled in heaps, where a gradual heating of the mass takes place, with the production of polysulphurets, and finally hyposulphite. The material is then lixiviated and the residues again exposed to the oxidizing action of the atmosphere; another lixiviation followed by another exposure, and so on till three or four lixiviations of the mass have been made, practically exhausts it. The hot chimney gases are passed through to accelerate the conversion of the sulphide of calcium into hyposulphite, as they have been found to be well adapted for the purpose, and to reduce the duration of the operation from several days to eight or ten hours. The liquors from the different lixiviations are all collected in one receptacle, and hydrochloric acid added, which precipitates sulphur and expels sulphurous acid—

$$CaS_2O_3+2HCl=CaCl_2+SO_2+S+H_2O.$$

The sulphurous acid is caused to pass through solutions containing polysulphides of calcium, which determines a precipitation of a part of their sulphur, leaving the remainder in the state of hyposulphite, ready for the action of hydrochloric acid—

$$2CaSx+3SO_2=2CaS_2O_3+Sx.$$

Schaffner & Helbig's method.

Schaffner & Helbig's method.

The processes adopted and used for the past fifteen years for the recovery of the sulphur from soda waste have almost universally been similar to those described above, and based on the same principles. They, even when most successfully practiced, do not allow of more than 50 to 60 per cent. of the sulphur contained in the residues to be

Soda industry.

recovered as such, while the lime and the remainder of the sulphur forms a secondary waste product which is not utilized at all, and to get rid of which is expensive.

Regeneration of sulphur from soda waste.

The method of Schaffner & Helbig has for its object the recovery of practically the whole of the sulphur and lime in the residues, both in a state especially adapted for reuse in the soda industry. It is based principally on the fact (1) of the possibility of applying the chloride of magnesium to the decomposition of the sulphide of calcium, according to the following equation:

Schaffner & Helbig's method.

$$CaS+MgCl_2+H_2O=CaCl_2+MgO+H_2S;$$

Theory of the process.

and (2) by the reaction which takes place when sulphureted hydrogen and sulphurous anhydride in proper proportions come together, resulting in the production of sulphur and water—

$$2H_2S+SO_2=3S+2H_2O.$$

The sulphurous anhydride taking part in this reaction is derived from the combustion of pyrites, of sulphur, or of a part of the sulphureted hydrogen itself.

Prevention of the formation of pentathionic acid, &c.

The inventors state that they have discovered a means of obviating the formation of pentathionic acid and other sulphur compounds which are usually produced in the reaction between sulphureted hydrogen and sulphurous anhydride, by employing solutions of chloride of calcium or chloride of magnesium as solvents for the gases.

The magnesia resulting from the reaction of chloride of magnesium on sulphide of calcium is reconverted into chloride by means of chloride of calcium and carbon dioxide—

$$MgO+CaCl_2+CO_2=MgCl_2+CaCO_3.$$

Advantages of the method.

The following advantages are claimed for this method: (1) It is simple and safe; (2) the treatment of residues requires much less time than is necessary in the methods hitherto employed for the same purpose; (3) the expense for labor is less than by older processes; (4) it is practicable to recover 90 to 95 per cent. of the sulphur contained in the waste, against 50 to 60 per cent. by the usual means; (5) 70 to 75 per cent. of all the lime contained in the residues are regenerated in a proper form and condition to be used again in the soda fabrication; and (6) the total expense in the regeneration of sulphur is much less than formerly.

The reader is referred to the accompanying plates for figures and explanations of the apparatus for the regeneration of sulphur and of carbonate of lime by this new process of Schaffner & Helbig.

Soda industry. **SCHAFFNER & HELBIG'S METHOD FOR THE REGENERATION OF SULPHUR.**

Regeneration of sulphur from soda waste.

EXPLANATION OF THE PLATES.

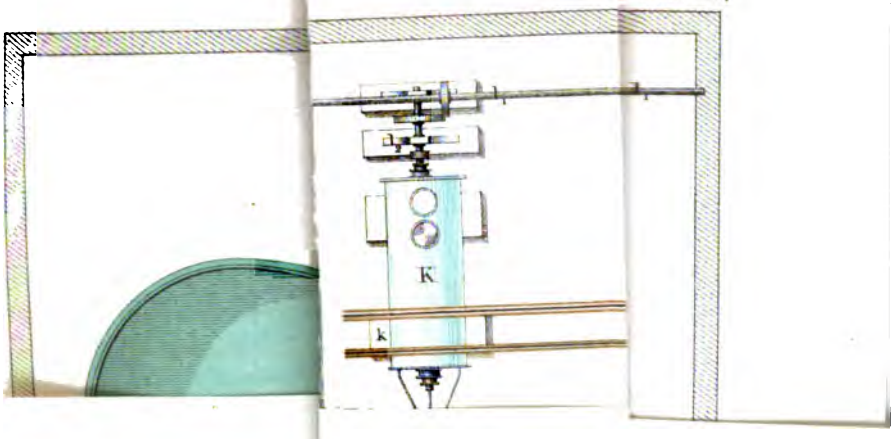
(The same letters refer to the same parts.)

Schaffner & Helbig's method.

Description of the plates.

A. Funnels conducting the "waste" into the sulphureted hydrogen generator.
B. Vessel for the disengagement of sulphureted hydrogen, with stirrer.
C. Decomposer for the reaction of sulphureted hydrogen and sulphurous acid.
D. Receptacle for the precipitated sulphur, with stirrer.
E. Machine for moving stirrers.
F. Filter for the sulphur.
G. Cistern for liquids from filter F.
H. Pump for raising the solutions to the reservoir for the decomposer.
J. Reservoir surmounting decomposer.
K. Cylinder provided with stirrer for fusing the sulphur.
L. Machine for moving stirrer.
M. Settling vessel for scoriæ, with stirrer.
N. Machine for moving stirrers in B and C and the screw in A.
O. Reservoirs for magnesia and chloride of calcium, with stirrer.
P. Pumps for raising solutions of cloride of calcium with magnesia into the carbonators.
Q. Carbonators.
R. Settling vessels for carbonate of lime.
S. Filters for the carbonate of lime.
T. Cisterns for solutions of chloride of magnesium coming from the carbonate of lime settling vessels.
U. Cistern for the wash-waters from chloride of magnesium.
V. Pump for raising solution of chloride of magnesium to the reservoirs.
W. Reservoirs for the solution of chloride of magnesium.
a. Railway for the transport of "waste."
a^1. Screw for charging "waste" through the funnels.
b. Conducting tubes for the sulphureted hydrogen.
b^1. b^2. Entrance tubes for the sulphureted hydrogen into the decomposers.
c_1. c_2. Entrance tubes for the sulphurous acid into the decomposers.
d. Communication of the decomposers with the chimney.
d_1. d_2. Conduit tubes to the decomposers.
e. Trough for draining off liquid holding precipitated sulphur to the settling vessels.
e_1. Communication between the settling vessels.
e_2. Bevel-wheels to stirrers of settling vessels.
f_0. Tubes for drawing the sulphur on the filters.
f_1. Overflow pipe of the settling vessels.
f_2. Stop-cocks for drawing off filtered liquors.
f_3. Stop-cocks for drawing of contents of filters.
g_1. Trough for liquid running from settling vessels.
g_2. Trough for the contents of the sulphur filter.
h_1. Tube for aspirator or pump H.
h_2. Tube for filling tank surmounting decomposers.
i_1. i_2. Tubes for distributing the solution from J to the decomposers.
k. Railroad for transport of sulphur to melting boiler.
k_1. Trough leading off water from the sulphur-melting boiler.
l_1. Shaft, l_2. Gearing, for sulphur-melting boilers.
m_1. Spout for drawing off mixed liquors.
m_2. Spout for drawing off settled liquors.
m_3. Discharge for residues.
m_4. Railroad for transport of residues.
n_2. Shaft of machine moving the charging screw of funnels.
n_3. Shaft of machine moving stirrers in vessel for disengagement of HS.
n_m. Shaft of machine moving stirrer in settling vessels.
o. Trough for distributing the lyes.
p_1. Tube of aspirator.
p_2. Tube of pump for raising solutions of chloride of calcium and magnesia to carbonators.
q. Carbonic acid conduit from blowing-engine.
q_1. q_2. Conduit tubes for carbonic acid leading to carbonators.
r. Discharge pipe for carbonate of lime to settling vessel.
r_1. Stop-cock for drawing off chloride of magnesium solution.
r_2. Trough for chloride of magnesium lessives.
s_1. Stop-cock for drawing off the mud from filter.
s_2. Railroad for transport of carbonate of lime to the driers.
t_1. Pipes for the strong chloride magnesium lessives.
t_2. Pipes for wash-waters of the filters.
u. Trough for the wash-waters.
v. v_2. Pump and tubes for raising solution chloride magnesium from cistern to W.
w_2. Stop cock and tube for supplying chloride magnesium to vessel B.

Plate I.



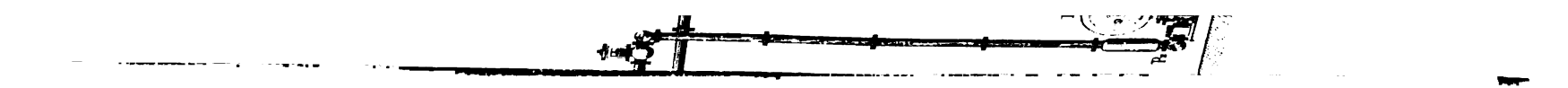
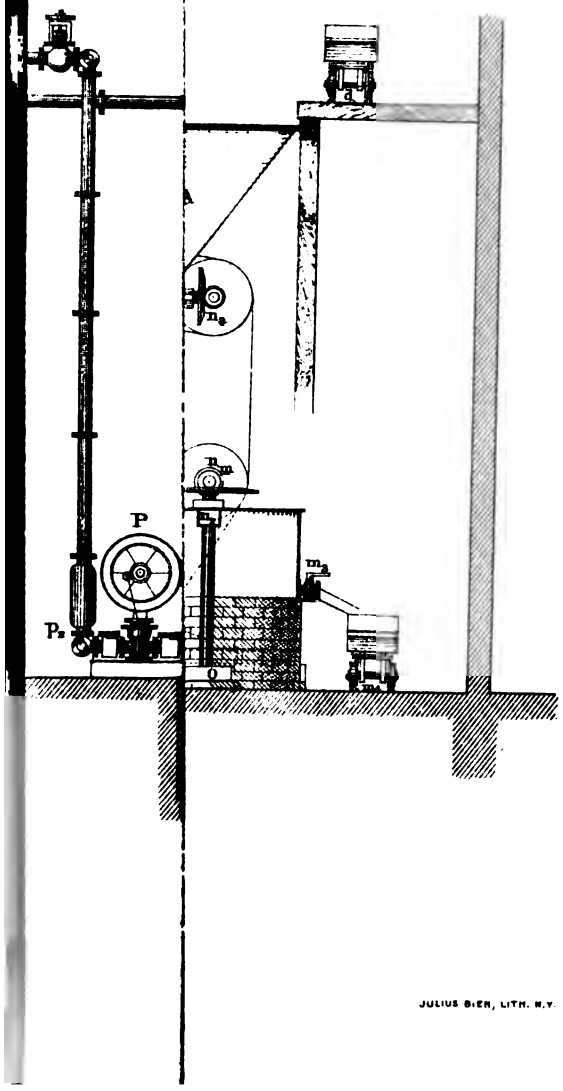


Plate II.



JULIUS BIEN, LITH. N.Y.

Krausshaar's method.

Regeneration of sulphur from soda waste.

By this method the residues are exposed to the action of water out of contact with air. Under these conditions hydrate of lime and sulphydrate of calcium are formed. When the mass is then exposed to the action of the air polysulphides are first formed and, later, hyposulphite. The oxidation is interrupted at the point where the lyes contain one molecule of hyposulphite and one molecule of sulphydrate to two molecules of sulphite of calcium, and hydrochloric acid added precipitating the sulphur and causing no disengagement of sulphureted hydrogen. The process is continuous, acid and lye entering at the bottom of a heated reservoir and sulphur flowing off at the upper part.

Krausshaar's method.

Mactear's method.

Mactear's method.

In this method use is made of the liquor obtained by the natural drainage of accumulated heaps of soda waste. There are three modifications of it: (1) A small quantity of lime is added to the liquors and sulphurous anhydride is introduced. The solution is then decomposed by hydrochloric acid at 60° C. While the results are good, it is difficult to completely avoid the evolution of sulphureted hydrogen. (2) The modification in successful operation during the past five years. An aqueous solution of sulphurous acid obtained from pyrites or regenerated sulphur is added to the yellow liquors, and the mixture is decomposed by a stream of hydrochloric acid in a decomposing vessel at 62° C. A plant costing $10,000 gives a yield of thirty-five tons weekly at a cost of about $15 per ton. (3) For very weak liquors, a solution of bisulphite of lime in sulphurous acid is used, the bisulphite being obtained from old waste heaps. Mactear finds it more economical to use hydrochloric acid for the regeneration of sulphur than in the manufacture of bleaching powder. The sulphur obtained by all these methods is purified by Schaffner's process, viz, fusion in steam at a pressure of 1¾ atmospheres. As executed in Schaffner's own works this process gives a regenerated sulphur the exact appearance of the Sicilian article, and frees it from the odor of sulphureted hydrogen hitherto clinging persistently to sulphur obtained by these processes of regeneration.

Three modifications.

Hewitt.

Hewitt's process.

Proposes to fuse soda waste with silica in a current of air, obtaining thereby sulphurous and sulphuric acid, together with silicate of lime.

Soda industry.

Ammonia-soda.

Ammonia-soda process by E. Solvay of Belgium.

The ability of this new method of soda manufacture to maintain its existence and successfully complete with the Leblanc process can now be regarded as fully settled, although more than once since the recognition accorded to the unbounded ingenuity and perseverance of E. Solvay at Belgium, in 1873 doubts have been expressed by leading authorities as to its eventual success.

Full experience with this process may enable it to supersede the Leblanc process.

When this process shall have become possessed of a fund of experience as ample as that on which the Leblanc process is based, it is scarcely to be supposed that the latter will be able longer to maintain its existence. Still, the amount of experience underlying the new method is by no means small.

The nature of the reaction.

The simplicity of the fundamental reaction in the manufacture—the decomposition of common salt in solution by bicarbonate of ammonium into insoluble bicarbonate of sodium and chloride of ammonium, and the regeneration of the ammonia by treatment with lime—as contrasted with the cycle of reactions involved in Leblanc's process, attracted the attention of technical chemists long since. As early as 1838, the method was patented in England by Dyar, Gray, Harrison, and Hemming. The great expectations then harbored of a revolution in the soda manufacture were,

The history of the invention.

however, not realized. Subsequently extensive experiments were made by Deacon and by Gossage at Widnes (1855); by Bowker at Leeds, and by Muspratt at Newton, in England; by Schlösing and Rolland at Puteaux (1855); by Türk at Nancy (1854); by Nickles at Nancy (1865); by Margueritte and Lourdeval at Paris (1866), in France; and

Partial success.

at Vilvorde, in Belgium (1842). Failure attended all of these attempts with the exception of that of Schlösing and Rolland, which from other circumstances, however, was short lived, chiefly on account of the imperfections of the

Difficulties encountered in the economical execution of the theoretically simple process.

apparatus used. Simple as are the reactions occurring in the process, their economical execution, and especially the avoidance of a loss of the costly reagent ammonia, demanded apparatus of a very much more complicated character and exact adaptation than had hitherto been requisite in soda manufacture. It is in the invention and perfecting of the

Eventual success of Solvay.

apparatus, and the skillful and satisfactory combination of the many necessary parts of it, that has enabled Solvay to carry to a successful issue this simple (in theory) process. The experiments commenced by him in 1861, and carried on with no slight outlay of capital before attaining a degree of perfection insuring financial success, are still being ardently

Soda industry.

Ammonia-soda process.

prosecuted, each year witnessing some new change or addition, most of which aim at reducing the loss of ammonia to a minimum.

Process adopted at the Solvay works.

As now established in the works of Solvay, the decomposition of the salt in solution is effected in vertical cylinders 12 to 18 meters in height, into which the carbonic acid is admitted under a pressure of 1½ to 2 atmospheres. The great advantages of this process are: (1) A single innoxious by-product—chloride of calcium; (2) the production of a carbonate of soda almost perfectly pure. With regard to this latter point it seems probable that the combination of Hargreaves's sulphate with Mactear's decomposition process is destined to yield a product but little inferior to that obtained by Solvay. The chief objections still urged against the process are: (1) The loss of ammonia. This loss, which amounts to scarcely 1 per cent. of the weight of soda obtained, is, however, fairly balanced by the saving in another nitrogenous substance—nitrate of sodium—of which such enormous quantities are consumed yearly in the manufacture of sulphuric acid required for Leblanc's process. (2) The old process possessed certain advantages in allowing the preparation of caustic soda, soda crystals, etc., from secondary products of but slight value. In this connection Solvay believes that there is no demand for soda crystals otherwise than on account of the purity guaranteed by their appearance, while soap manufacturers and others who use caustic soda require it almost invariably in solution, and will recognize that it is more economical to meet their wants by rendering solutions of carbonate of soda caustic in their own establishments, thereby saving the cost of preparing the solid caustic soda necessary for the transport. (3) The process does not yield hydrochloric acid, the important by-product in Leblanc's process. With regard to this objection, Solvay is sanguine of finally perfecting a method for utilizing the chlorine originally present in the salt used. The processes already patented by him involve the preparation of hydrochloric acid by heating chloride of calcium with silicic acid, alumina, or simply clay in the presence of aqueous vapor, and the preparation of chlorine by substituting in the above reactions a current of dry air for aqueous vapor. The residual aluminates or silicates can be used for the preparation of hypochlorites by exposure to chlorine in a moist state, yielding at the same time precipitated silica or alumina; or can replace lime and magnesia in the regeneration of ammonia, forming the resultant chlorides, likewise

Advantages of the process.

Objections:

Loss of ammonia.

Does not admit of making soda crystals, etc., from cheap secondary products.

The process does not yield hydrochloric acid.

Proposed preparation of hydrochloric acid and chlorine.

Utilization of the waste.

Soda industry. silica and alumina, which can be repeatedly used for this purpose.

Ammonia-soda process. Schmidt gives the following as the necessary proportions for the production of 100 kilos of soda, when the process is carried out on a large scale:

Proportions of materials for 100 kilos of soda.

	Kilos.
Salt	180–200
Coal	105
Coke	23
Sulphuric acid	1
Limestone	80
Sulphate of ammonium	5

Cost of manufacture at Nancy. The cost of manufacturing soda in Solvay's works at Nancy is stated on good authority to be less than $20 per ton.

Uses of the ammonia-soda. The ammonia-soda is now in constant demand by ultramarine works. It is also in high favor with glassmakers, the dissatisfaction with the voluminous character of the product first placed on the market having caused the manufacturers to produce a denser or more compressed article.

Places where the Solvay process is worked in Belgium, Solvay's process is now in successful operation in the mother establishment at Couillet, Belgium, producing

France, 7,500,000 kilos annually; in the French branch at Verangéville-Dombasle, which turns out 20,000,000 kilos yearly, where the productive capacity is shortly to be doubled;

England, and in the two English establishments of Brunner, Mond & Co., at Northwich and Sandback, yielding 13,000,000 kilos yearly; making a total of 40,500,000 kilos annually, corresponding to 46,000,000 kilos of ordinary soda. In

Denmark. Denmark there are one or two establishments in operation or starting. Large works erected at Kasan, in Russia, a few years since, have failed from lack of careful management. The same may be said of several attempts made in Germany. There are, however, in the latter country at least two establishments now producing ammonia-soda, although the methods are not exactly the same as that used by Solvay. One of these, at Schalke, in Westphalia, makes use of

Modified process at Schalke, in Westphalia; a process not yet described. The soda there produced contains 98.9 per cent. of carbonate and 0.73 per cent. of water—a purity as high as that obtained at Couillet. M. Honigmann,

and at Grevenberg. in Grevenberg, near Aix-la-Chapelle, has manufactured ammonia-soda successfully for several years by a method of manipulation somewhat different from that employed by Solvay. All operations are performed in cylindrical vessels. A battery of six, 3 to 4 meters in height and the same in diameter, furnish a daily production of 5,000 kilos. The

Soda industry.

material used for constructing the cylinders is iron plate of 5 to 9 millimeters in thickness. The precipitation of the bicarbonate is effected by forcing the gases from a lime kiln (32 per cent. of carbonic acid) through a series of three cylinders containing the solution of ammonia and salt, forming together a column of liquid 6 to 7 meters in height. The heat arising from the absorption of the carbonic acid is moderated by a stream of cold water, so that the temperature does not rise above 35° C. The separation of the bicarbonate from the solution of chloride of ammonium is effected by powerful centrifugal filtering apparatus, and regeneration of the ammonia is accomplished by means of the waste steam from the machine. About 50,000 kilos of residual solution, containing 12.5 per cent. of chloride of ammonium and 2.5 to 3 per cent. of carbonate of ammonium, are treated with slaked lime daily in these works. The soda obtained contains 97.8 to 98.5 per cent. of carbonate, the remainder being water and chloride of sodium. A boiler of 180 square meters surface supplies the necessary steam power to effect movements—pumping, agitation, etc.—of the liquids, etc., involved in a daily production of 5,000 kilos of soda. The number of operatives necessary to turn out this amount of product is 11 by day and 8 by night, while a contractor with 9 workmen supplies raw material and removes waste products. Honigmann consumes the following quantities of raw materials in the production of 100 kilos of soda on the scale above described:

Ammonia-soda process.

Honigman's modification of the Solvay process.

	Kilos.
Salt	250
Coal	145
Coke	35
Limestone	100
Chloride of ammonia (lost)	5
Sulphuric acid	½

Consumption of materials per 100 kilos of soda produced.

These works are being enlarged to a daily productive capacity of 30,000 kilos.

The carbonate of soda obtained by the ammonia process is almost absolutely pure; it is quite free from causticity and contains a mere trace of iron. The freedom of the product from iron and from sulphate of sodium renders it especially applicable in glass-making, and its use is very general in Belgium and England, and to some extent in this country in glass works making the finer qualities of crystal and plates. Its use in glass-houses has been followed by a longer wear of the pots, but the temperature of the furnace has to be kept well up.

Purity of the carbonate of soda produced.

Value for glass-making.

Soda industry.

Ammonia-soda, composition of a commercial quality.

The following is a statement of the percentage composition of a commercial product:

Water	0.147	0.147
Silica and carbon	0.053	
Chloride of sodium	0.064	
Oxide of iron	0.003	
Alumina	0.009	
Carbonate of calcium	0.071	
Carbonate of magnesium	0.021	0.221
Carbonate of sodium	99.632	99.632
		100.000

Changes in the ammonia-soda process.

The most important changes in the ammonia-soda process are the following:

Schmidt combines it with the kelp industry.

Schmidt, in Denmark, combines it with the kelp industry in a very ingenious manner. From the liquors obtained by the lixiviation of sea-weed ashes, the sulphuric acid is precipitated very exactly by the addition of the residual chloride of calcium solution from the ammonia-soda process. Iodine and bromine are next precipitated by addition of nitrate of lead. In the filtrate the chloride of potassium present is changed into nitrate by the addition of nitrate of sodium, and separated by crystallization. The residual solution of chloride of sodium is then well adapted for the ammonia-soda process.

DeGrousilliers precipitates bicarbonate of sodium by dilute alcohol.

De Grousilliers has devised a method for precipitating the bicarbonate in dilute alcohol, which, by means of apparatus invented by W. Siemens, has been introduced into Kunheim's works at Berlin. It is based on the fact of the almost total insolubility of the bicarbonates of soda or potash in dilute alcohol, and the ready solubility of the alkaline chlorides, of ammonia, and of carbonic acid in the same menstruum. The apparatus consists of a cylinder containing alcohol of 35 per cent., into which pulverized salt, ammonia, and carbonic acid are introduced. The reaction is hastened by stirring, and on completion the precipitated bicarbonate is filtered off and the residual liquor treated with lime, regenerating the alcohol and the ammonia. The losses of ammonia and alcohol referred to the weight of soda produced are respectively 0.01 per cent. and 0.1 per cent.

Advantages.

The advantages claimed for the process are: Smallness of apparatus in comparison with its productive capacity, a minimum of manual labor, and the slight loss of ammonia involved.

Scherbascheff method of avoiding the formation of the bicarbonate of sodium.

Scherbascheff proposes to avoid the formation of bicarbonate of sodium in the ammonia process by taking advantage of the fact that when carbonate of ammonium is added

Soda industry.

to a solution of chloride of sodium at 60° to 70° C., the salt, represented by the following formula—$Na_2CO_3 + H_2O$—is precipitated. Ammonia soda.

An interesting modification of the principle underlying this process has been introduced by G. T. Gerlach, of Kalk, Westphalia, in which the manufacture of soda is rendered subsidiary to the production of ammonia salts from gas water. It is essentially as follows: Gerlach's process subsidiary to the production of ammonia salts from gas water.

A concentrated solution of carbonate of ammonium is prepared by the distillation of gas water, and in this an equal quantity of salt is dissolved. Carbonic acid is introduced until the precipitation of bicarbonate of soda ceases, when the latter is separated from the liquid by means of a centrifugal filter. The filtrate contains carbonate of ammonium, which is obtained by distillation, and chloride of ammonium and undecomposed chloride of sodium, which are easily separated from each other by crystallization. The chief peculiarities of the method are the economical utilization of gas water, including the carbonic acid there present; the absence of by-products, as well as of the loss of salt unavoidable in the Solvay process, and the loss of ammonia likewise accompanying the same process; the saving in fuel effected by eliminating from the process the constant regeneration of caustic ammonia. Gerlach has also perfected methods for replacing the salt hitherto used by sodium sulphate or nitrate, obtaining thereby, with sodium carbonate, sodium, sulphate, or nitrate. Nature of the process. Peculiarities of the method.

Ingenious and economical as this method is, it must not be forgotten that the supply of gas water is limited. From statistics gathered in 1873, it is estimated that 25,000,000,000 kilos of coal are consumed annually in gas works. As 100 kilos of coal yield on an average 0.3 kilo of ammonia among the products of distillation, the total annual yield of this body from this source is 75,000,000 kilos. This quantity, according to Gerlach's method, would furnish the basis for a production of but 230,000,000 kilos of soda, an amount but little over a quarter of the production of Great Britain alone. It is therefore evident that while this method may be advantageously pursued in combination with the production of ammonium salts, the limited quantity of the latter, as well as the impossibility of bringing more than a fraction of the gas water produced within reach of the manufacture, will prevent it from assuming dimensions of any great magnitude. Limitations of the process. Yield of ammonia per kilo of coal. Calculation of the total yield from this source.

A similar modification of the ammonia-soda manufacture is proposed by Claus & Wallace, in which the preparation Claus & Wallace's process.

Soda industry. of soda plays a subordinary part to the purification of illu-
Ammonia soda. minating gas. Caustic ammonia in a series of scrubbers is
Claus & Wallace's process. used for the entire purification of gas issuing from the retorts. The arrangements are such that the gas on entering the series encounters first a solution in which the ammonia is nearly saturated with carbonic acid, and passes successively through weaker and weaker solutions. The saturated solutions, after concentration, are mixed with salt solutions, and the usual decomposition is effected with the carbonic acid resulting from the calcination of bicarbonate. The
Advantages. regeneration of the ammonia is accomplished by means of lime as usual. By this combination of the two processes a single operation suffices to purify the gas, utilize its carbonic acid, avoid the preparation of carbonate of ammonia otherwise incident to the manufacture of soda, and avoid the production of any useless by-product other than the chloride of calcium, which is harmless and easy to remove. By this method it is estimated that the coal consumed in gas works would yield 4 per cent. of its weight of refined soda.

Possible weekly yield in soda of the London gas works. The gas works of London would yield about 1,200,000 kilos of soda weekly. Taking the above-mentioned estimate of the entire annual consumption of coal in gas works, viz, 25,000,000,000 kilos, as a basis, it is evident that the introduction of this process would permit the production in connection with gas manufacture of 1,000,000,000 kilos of pure soda annually, an amount equal to the united product of France and England.

The technical realization of this plan will be looked for, therefore, with no slight degree of interest.

New soda methods.

NEWLY PROPOSED METHODS FOR THE MANUFACTURE OF SODA.

In no branch of chemical manufacture are so many novel and original propositions brought forward as in the preparation of soda. Apart from the modifications of the methods already in use, noted as above, the following projects may be briefly mentioned:

C. Vincent. C. Vincent proposes to prepare sulphide of sodium by the action of sulphide of barium on sulphate of sodium, and change the sulphide to carbonate by the action of carbonic acid.

E. Davis. E. Davis heats together Rhodondo phosphate, sulphate of soda, and coal. The solution obtained by lixiviation yields, on treatment with lime or chalk, caustic soda or the carbonate, and tricalcium phosphate, which is utilized for superphosphates.

Soda industry.

E. Bohlig makes use of oxalate of magnesium as the means of conversion, the reactions being as follows:

Proposed new methods. E. Bohlig.

$$C_2O_4Mg+HCl+NaCl=C_2O_4HNa+MgCl_2;$$
$$C_2O_4HNa+MgCO_3=C_2O_4Mg+NaHCO_3;$$
$$2NaHCO_3+MgO=Na_2CO_3+MgCO_3+H_2O.$$

The chloride of magnesium is decomposed by heat and steam into magnesia and hydrochloric acid.

Grüneberg & Forster. Grüneberg & Forster treat a mixture of chloride of sodium and alumina with superheated steam at a red heat. Hydrochloric acid escapes and the resulting aluminate of soda is decomposed by lime or chalk.

Thirion. Thirion has introduced a process into France by which the sulphate of sodium is heated with coal and silicic acid. The products are silicate of sodium, sulphur, sulphurous anhydride, and carbon monoxide. The silicate of soda can be used as such in glass-making or changed into soda or caustic soda. One-half of the sulphur is regenerated, and the other half, in the form of sulphurous acid, utilized for the manufacture of hydrosulphites.

W. Weldon. W. Weldon melts sulphate of sodium and pours it on red-hot coal. The carbonic oxide set free is used for making bicarbonate, and the residual sulphide of sodium converted into caustic soda by the action of steam, or into bicarbonate by passing a current of carbonic oxide through the solution.

Caustic soda.

Caustic soda.

No essential changes have been introduced into the preparation of caustic soda, either in the extraction from the mother-liquors of soda works or in the treatment of the carbonate with lime. In addition to the proposed methods above noticed, yielding at will carbonate of sodium or caustic soda, the following processes have been advocated:

Arrott decomposes a mixture of salt and phosphate of iron by steam, condenses the hydrochloric acid evolved, and treats the solution of phosphate of sodium obtained by lixiviation with lime.

Löwig heats a solution of aluminate of sodium (or potash) with slaked lime, obtaining a solution of caustic alkali and a precipitate of aluminate of calcium, from which hydrated alumina is easily prepared.

MANUFACTURE OF CHLORINE AND BLEACHING POWDER.

Chlorine and bleaching powder.

For the preparation of chlorine no new methods have been introduced during the past five years. Solvay's pro

Chlorine and bleaching powder.

posed plan for the formation of chlorine from the residual chlorides of the ammonia-soda process has not yet been technically realized. The two methods now prevalent are those of Weldon and of Deacon & Hurter, both introduced about ten years since.

Weldon's process.

Weldon's process, the invention of which was incited by the rapid diminution in the natural supply of peroxide of manganese, resembles greatly the ammonia-soda process, the stock of peroxide of manganese in use being constantly regenerated, and chloride of calcium remaining as a waste product. It has not been materially modified of late, and consists simply in the addition of lime to the residual

Description of the process.

liquors after the treatment of the peroxide with hydrochloric acid, while a strong current of cold air is blown through the liquid. The precipitated hydrate of manganous oxide is thus oxidized to the state of peroxide, and obtained in the form of calcium manganite, $CaMnO_3$, or of a combination of 1 molecule of lime and from 1 to 2 molecules of peroxide of manganese, in which forms it is ready for repeated treat-

The present favorite method.

ment with hydrochloric acid. Weldon's process is now used for the preparation of most of the bleaching powder made in England, and is widely used on the Continent, most of the French works having introduced it within three or four years.

Difficulties in the regeneration of the oxide of manganese.

It occasionally happens during the oxidation of the manganous oxide that instead of becoming black the mixture presents a brown or reddish color, owing to a transformation of the oxide into the $\frac{3}{4}$ oxide—Mn_3O_4—instead of peroxide, MnO_2. This incomplete oxidation takes place when the insufflation of air is too rapid and strong before the addition of the lime or when too little of that substance is employed. No convenient remedy has as yet been discovered for this accident, and it is found to be necessary to redissolve the whole precipitate in hydrochloric acid and recommence the operation of regeneration. Sometimes, on account of insufficient force in the stream of air from the blowers, or when a great excess of lime has been added, or the temperature of the manganese residues is too high, the precipitate consisting of the oxide of manganese and lime becomes thick, accumulates in masses, and is practically impervious to the incoming current of air. When this accident happens, it is always at the beginning of the operation, and the current of air finds difficulty in making its way through the mass and finally stops. In order to remedy this inconvenience an additional amount of cooled manganese

liquors must be added and the blowing apparatus urged to its fullest extent. *Chlorine and bleaching powder.*

Jetzler's improvement, introduced in 1874, is in satisfactory operation in a Swiss and a German establishment. It consists in the use of a current of hot air, rendering the oxidation more complete, and giving to the regenerated peroxide a powdery character, so that it can be used in the old-style apparatus for the disengagement of chlorine. Jetzler's method of regenerating the oxide of manganese.

The two precursors of Weldon's process—the methods of Dunlop and Hoffmann—although still in operation, have never been introduced into works outside of those in which they originated. In the great works of St. Rollox, where Dunlop's method was employed, a Weldon apparatus has been erected to supply a portion of the chlorine needed. The Dunlop and Hoffmann methods.

While Weldon's process aims at a constant regeneration of the substance necessary to effect the decomposition of hydrochloric acid, Deacon & Hurter seek to replace the whole cycle of chemical operations involved in the use of peroxide of manganese, and its subsequent regeneration, by simply passing a mixture of air and hydrochloric acid gas over a catalytic substance. According to their method, the mixture of air and hydrochloric acid gas issuing from the sulphate furnaces of the soda works is conducted through tubes heated to about 400° C., and filled with porous bricks which have been saturated with sulphate of copper. The ensuing decomposition into aqueous vapor and chlorine results from the well-known property of copper salts to yield up oxygen to other compounds (while renewing their supply from the air), and from the partial decomposition of hydrochloric acid and air effected by contact with porous substances. This process is theoretically so simple, and gives such satisfactory results when first installed, that it was regarded as destined to supersede the use of peroxide of manganese, and it was introduced into twelve English and two German works. As in many other technical innovations, it was soon found that the process was attended with a serious impediment. After the lapse of a few months, the porous masses lost their power in a great measure, and even entirely, of determining the dissociation of hydrochloric acid, and considerable losses were incurred in consequence of interruption, delays, and changes due to this unforeseen obstacle. In a majority of the works, where the method had been adopted at great outlay of money in the installation of the apparatus necessary to carry out the process on a large scale, it was entirely set aside. This failure to meet the expectations based on the otherwise attendant advan- Deacon & Hurter process. Description of the process. Favorably received, but not permanently successful. Generally abandoned.

Chlorine and bleaching powder.

Deacon & Hurter process.

tages of the method led to a careful study of the causes diminishing or arresting the catalytic action in the decomposer. The chief cause is found to be the presence of sulphuric acid in the hydrochloric acid gas issuing from the sulphate furnaces. The sulphates formed on the surfaces of the bricks offer a mechanical obstacle to the action of the copper salt, and the sulphuric acid is decomposed by the hot sulphate of aluminum into water, oxygen, and sulphurous acid. The latter is oxidized at the expense of the free chlorine, and gives rise to a continuous series of reactions, which contribute materially to lessen the amount of chlorine evolved. Antimony and arsenic are likewise found to gather on the bricks and exert a deleterious influence on the reaction.

Causes of the failure.

Attempts to avoid the difficulties cited:

In Germany,

In England.

Armed with the results of these investigations, those interested in the future of the process have sought to overcome the difficulties mentioned, as in the analogous case of Winkler's catalytic reaction for the manufacture of sulphuric anhydride. Hasenclever, in Germany, seeks to effect the most complete possible condensation of the sulphuric acid in the gases prior to their entrance in the decomposer; while in English works the apparatus is arranged with two decomposers, one of which is in operation while the other is being recharged, thus preventing an interruption in the continuity of the operation. By these means it has been found possible, both in England and Germany, to bring this process to a point of exactness and regularity insuring its technical success in the future. The bleaching powder obtained by its means possesses 35 per cent. of effective chlorine.

Future probable success.

Supply of peroxide of manganese.

With regard to the supply of peroxide of manganese, it should be mentioned that extensive deposits of a rich ore have been found recently in the north of Spain and in the island of Mycone, near Syra.

Monographs on the composition of bleaching powder.

A number of papers have been published treating of the subject of the composition of bleaching powder, without, however, settling the still vexed question of its chemical formula, and an elaborate and minute study of all the phases in the preparation of this article, touching a number of important physical and chemical points, has been contributed to the literature of the subject by Hurter.

Bromine.

BROMINE.

Immense production in the United States.

The enormous quantities of bromine produced in this country have practically suppressed its production from kelp and from the mother-liquors of the Stassfurth salines in Europe; the cheapness of the American product hav-

Bromine.

ing rendered successful competition impossible. The daily production of this substance in Ohio, Pennsylvania, and West Virginia is put down lately at 700 kilos. For exportation and ocean transport it is converted into bromide of iron, ships refusing to take the liquid bromine on board. The demand for bromine has greatly increased since the discovery of eosines, bromated niter derivatives, etc., coloring matter from resorcine, and phtalic acid, etc. A number of propositions have lately been made to use it in the extraction or metallurgy of gold, mercury, platinum, etc., in chemical analyses, and finally as an oxidizing agent in the preparation of phosphoric and arsenic acids, ferridcyanide and permanganate of potassium. H. Hahn obtains bromine, when present in but small quantities, in mother-liquors of salt works, as follows: Chloride of silver is dissolved in the liquor, which is afterwards diluted with four times its weight of water, letting fall a precipitate consisting of chloride and bromide of silver, which is used repeatedly in the same manner until it is sufficiently rich in bromine, which is then separated. The immence production of bromine, during late years, has caused a fall in its price from $7.50 to 30 cents per pound.

United States production has suppressed European production from kelp, etc.

Increased use and demand.

H. Hahn's process.

Fall in price to one-twenty-fifth of its former value.

IODINE.

Iodine.

The serious if not fatal blow inflicted on the European manufacture of bromine by the rapid development of its production in North America is fully equaled, in the case of iodine, by the enormous exportation of this substance from South America, where it forms an important by-product in the nitrate of sodium works. Hitherto the manufacture of iodine was confined almost entirely to Scotland and France, where it is obtained from kelp; the former country yielding 50,000 kilos annually, the latter 40,000 kilos. The nitrate of sodium of Peru contains about 0.16 per cent. of iodine, and is capable of affording an annual yield of 900,000 kilos. As its separation from the mother liquors in the form of iodine of copper is attended with no great difficulties, the appearance of the Peruvian product in the European market lowered the price from $20 to $4 in 1876. At present the price is somewhat higher in consequence of a temporary arrangement between the Scotch, French, and Peruvian manufacturers. There is, however, but little probability that the European manufacture can long maintain its existence, and at present a number of the works are at a standstill in France, the country where iodine was discovered and where the methods of its extraction have been so carefully elabo-

European manufacture seriously crippled by Peruvian competition.

Scotch and French manufacture from kelp.

Proportion of iodine in the Peruvian nitrate of sodium.

Fall to one-fifth of former price.

Iodine discovered in France.

Iodine.

rated. Despite the unpromising prospects for the kelp industry, strong efforts are being put forth by the French manufacturers to perfect their processes to such an extent that competition can successfully be attempted with the South American product. These efforts are in two directions: First, in the selection of the algæ used, and, secondly, in the process of extracting the iodine contained in the plants. With regard to the choice of sea-weed, careful analyses show that the floating red varieties of *Fucus* contain the largest amount of iodine. Thus, per ton of ash—

French attempts to retrieve their position.

Relative yield in iodine of seaweeds.

Fucus.

Fucus digitatus yields..... 10–28 kilos of iodine.
Fucus saccharinus yields..... 8–18 kilos of iodine.
Fucus bulborus yields..... 6 kilos of iodine.

Algæ.

On the contrary, the black algæ growing along the coast give but 1 to 4.5 kilos of iodine. The quantity of iodine increases also with the slowness of the growth, and the more northerly the region, the kelp of Scotland being richer in iodine than that of France. In the treatment of the seaweed more care is taken in the drying, the incineration, etc. Despite its manifold advantages, the method of incinerating the plants in furnaces has not yet been extensively introduced, the cost of fuel and transport to the furnaces generally standing in the way of its practical realization. For a number of years it has been carried on by Stanford, of Glasgow, who utilized the residual coal after lixiviation as a deodorizer. Glaizat and Pellieux and Mazé-Launay, in France, have likewise made attempts to introduce modifications of the method of dry distillation, which are still in operation on a limited scale. Herland extracts the salts from algæ by endosmose, immersing the plants in lime-water. By this process the yield of iodine is increased threefold. Schmidt extracts the iodine from the saline solution used in the ammonia-soda process, by precipitation as iodide of lead, prior to the separation of the potassium salts. In the extraction of iodine from kelp, Galloway proposes the substitution of chlorine water for Wollaston's method of treatment with sulphuric acid and peroxide of manganese. In a sample he determines the amount of chlorine water necessary to form iodine-pentachloride with the iodine present, and then adds sufficient to simply liberate the iodine. After its removal, sufficient chlorine is added to free the bromine present.

Northern seaweed the most productive of iodine.

Stanford's process.

Glaizat, Pellieux and Mazé-Launay.

Herland.

Schmidt.

Galloway.

Superphosphates.

SUPERPHOSPHATES.

In the manufacture of superphosphates but few changes are to be noted. Kohlrausch removes the 11 to 16 per cent. of carbonate of calcium from spodium prior to its change

Kohlrausch.

into superphosphate by treatment with sufficient hydrochloric acid to expel the carbonic anhydride and extraction of the chloride of calcium with a small quantity of water. J. T. Way goes still further, and accomplishes the entire transformation with hydrochloric acid, washing out the chloride of calcium with just a sufficiency of water. In Gratz the manufacture of superphosphate is joined in a very practical manner with the preparation of fertilizing material from the ordure of the city. An apparatus for the continuous manufacture of superphosphates has been devised by Thibault, and is now in satisfactory operation at Paris in Michelet's works, producing 30,000 kilos daily. It consists of a cast-iron cylinder, in which the dried phosphorite and sulphuric acid are introduced. A movable axle furnished with paddles arranged obliquely maintains not only a constant mixture of the mass, but also a gradual movement towards one end of the cylinder, where the liquid mass is conducted into brick chambers, lined with lead. The acid vapors disengaged are conducted through a coke scrubber in which water is constantly flowing, where likewise a small amount of iodine is deposited.

Superphosphates. Kohlrausch. Way. Gratz. Thibault.

Various studies on the reaction occurring in the decomposition of tribasic phosphate of calcium have been recently made. Kolb regards the reaction as consisting in (1) a rapid decomposition of two-thirds of the phosphate into sulphate of calcium and free phosphoric acid, and (2) a slow decomposition of the remaining third by the free phosphoric acid. Armsby, on the other hand, regards the reaction as consisting (1) in the decomposition of one-half of the phosphate to soluble phosphate—

Studies on the reaction which occurs. Kolb. Armsby.

$$Ca_3(PO_4)^2+2H_2SO_4=CaH_4(PO_4)^2+2CaSO_4,$$

and (2) in a gradual change of this soluble phosphate in contact with the remaining half of the triphosphate into insoluble dicalcium phosphate. Erlenmeyer finds that the salt $CaH_4(PO_4)^2+H_2O$ is completely soluble in 700 parts of water. A small amount of water is sufficient, however, to decompose it into free phosphoric acid and the insoluble $CaHPO_4+2H_2O$. This fact renders the extraction of phosphoric acid on the filter advantageous only with such phosphates as contain besides phosphate of calcium a certain quantity of free phosphoric acid sufficient to prevent the second reaction.

Erlenmeyer.

ALUMINA PREPARATIONS.

Alumina.

Sulphate of aluminium is now used extensively in the place of alum in the manufacture of paper and for dyeing

Sulphate of aluminium.

Alumina.

Alum cakes.

Turkey red. The English alum cakes used so extensively are prepared simply by the action of sulphuric acid on china clay, under a pressure of two or three atmospheres.

Sulphate of aluminium from slag.

A French company has introduced a method for preparing sulphate of aluminium from the slag of iron furnaces, by decomposing the latter with hydrochloric acid and precipitating hydrate of aluminium from the solution by means of carbonate of calcium.

Elimination of sulphate of iron.

Hutter's process.

An important improvement in the preparation of sulphate of aluminium, aiming at the elimination of the sulphate of iron so prejudicial in most of the applications of this article, has been made public by Alfred Hutter, of Montpellier. It is based on the fact that in a solution of sulphate of aluminium containing no free acid, but containing ferric sulphate, the introduction of strips of metallic zinc causes a precipitation of oxide of iron, attended with the formation of sulphate of zinc. The sulphate of zinc thus introduced serves admirably for the sizing of paper and could be used in large quantities for this purpose were it not for the high price.

Composition of the sulphate before and after treatment.

The composition of the sulphate before and after its treatment with metallic zinc is as follows:

	Before.	After.
Al_2O_3	15.40	20.85
SO_3	35.88	35.88
Fe_2O_3	0.95	0.04
ZnO		0.50
H_2O	47.77	42.73

It will be noticed that this reaction has also the effect of increasing the proportion of the crude sulphate.

Löwig. Hydrate of aluminium.

Process.

The Bros. Löwig, of Dresden, prepare a hydrate of aluminium well adapted for decolorizing beet-root juice by precipitating a solution of aluminate of sodium or potassium with hydrate of calcium, filtering from the solution of caustic alkali produced, and decomposing the precipitate of aluminate of calcium by sufficient hydrochloric acid to unite with the lime present.

Ducla's preparation of salts of aluminium.

Ducla prepares pure salts of aluminium from a hydrate obtained as follows: The solution of the crude sulphate of aluminium is treated with hydrate of calcium and carbonate of calcium. Carbonic anhydride escapes and hydrates of iron and aluminium are precipitated. The latter is extracted with solutions of caustic soda and precipitated for the alkaline solution by means of the carbonic anhydride liberated in the first instance.

BORAX AND BORACIC ACID.

Borax and boracic acid.

The use of borax is constantly increasing, its value as an antiseptic and for cleansing purposes being more and more generally recognized. The fumaroles of Tuscany, although producing annually 2,500,000 kilos of boracic acid, form no longer the chief source of this article and its derivatives. Among the most important new sources of boric compounds opened up within a few years are the extensive deposits in California and Nevada. They consist chiefly of borates of sodium and calcium, and form a zone in the volcanic region north and east of the Sierra Nevada. The annual production has already amounted to 2,400,000 kilos. Extensive deposits of boro-natro-calcite have also recently been discovered in Chili. Boric acid to the extent of about 140,000 kilos annually is obtained from the boracite in the Stassfurth deposits. The chief cause, however, of the recent notable diminution in the price of boric compounds is due to the development of the widespread deposits of borate and hydroborate of lime in Asia Minor, in the vicinity of the sea of Marmora and the Black Sea. These valuable sources were first recognized by C. Desmazures, who by their means was enabled in 1869 to introduce into France the industry of borax manufacture. The mines of Sussurbi have lately passed into the hands of Tennant, of the St. Rollox Works, Scotland; those at Panderma, which are capable of an annual production of 5,000,000 kilos, are being worked by a Constantinople firm, and the mineral—$2CaO,3B_2O_3+3H_2O$—yields 41 per cent. of boric acid. Boric acid is also obtained associated with chloride of ammonium on the island of Vulcano, north of Sicily. In the crevices of the crater of the volcano there is a constant issue of vapors, consisting of steam, sulphurous acid, and sulphur, which carry with them a certain amount of boric acid and chloride of ammonium. In order to gather the latter compounds the fissures are covered with a mixture of ashes and pumice stone, in which the sublimed matter is condensed. After four or five days it contains about 10 per cent. of boric acid, which is obtained by lixiviation. The annual production is but 4,000 kilos, and the process is interesting principally from the fact of its being constantly dependent on the activity of a volcano. Among the newer theories with regard to the cause of the appearance of boric acid in the fumaroles of Tuscany should be mentioned that of Dieulafait, who attributes its source to deposits of borates from the sea in

The fumaroles of Tuscany no longer the chief source.

Deposits of California and Nevada.

Production.

Chili.

Stassfurth.

Asia Minor.

C. Desmazures.

Mines of Sussurbi and Panderma.

Island of Vulcano.

Theories in regard to the fumaroles.

Dieulafait.

Borax and boracic compounds.

remote geological periods, from which the acid is released by the action of hydrochloric acid set free by the decomposition of chloride of magnesium in presence of aqueous vapor. Bechi, on the contrary, considers the boric acid to result from the slow decomposition by means of aqueous vapor of the borates so abundant in Italian serpentine.

Bechi.

Cyanides.

CYANIDES.

The applications of cyanides are becoming so extended that the necessity of a method for producing them cheaply in a state of comparative purity is being more and more keenly felt. Erlenmeyer proposes the following process, which, in view of the low price at which sodium is now produced in France, is possibly capable of technical realization. It consists in simply melting together ferro-cyanide of potassium and sodium, when the decomposition into metallic iron and cyanides occurs at once—

Erlenmeyer's process.

$$K_4FeCy_6+2Na=4KCy+2NaCy+Fe.$$

The mixture of the melted cyanides is poured off from the iron, which falls to the bottom of the crucible, and yields a salt capable of use for most purposes where cyanide of potassium is required. More attention is being given to the subject of the separation of the cyanogen compounds occurring among the waste products of various industries. Nietzki finds that soda works yielding daily twenty tons of soda could furnish annually as a by-product 6,500 kilos of ferro-cyanide of sodium and 3,250 kilos of sulpho-cyanide of sodium. The utilization of sulpho-cyanide of ammonium found in such large quantities in gas purifiers, and especially its transformation into the form of ferro-cyanide, have been the inciting cause of numerous researches. At Berlin and in England apparently satisfactory processes for bringing about this change have been in practical operation for over a year. Among the various methods suggested are the following:

Possible yield of sulpho- and ferro- cyanides by soda works.

Utilization of sulpho-cyanide of ammonium of gas works.

Douglas' process.

Douglas obtains ferro-cyanides from gas lime by mixing in it 5 per cent. of soda, extracting with water, evaporating to dryness, and heating the residue with iron filings.

Alander.

Alander heats a mixture of sulpho-cyanide of ammonium, coal, potash, and iron filings, made into a pasty mass by the addition of oil, to a dull red, and exhausts with water. By this means 40 to 60 per cent. of the sulpho-cyanide present is changed into ferro-cyanide.

Valentine.

Valentine heats the Laming mixture from the gas works with chalk or carbonate of magnesium; the solution obtained by lixiviating the mass contains ferro-cyanide.

Cyanides.

The most important novelty in this branch of industry is the synthetic preparation of ferro-cyanide of potassium by Tcherniac's process, the successful introduction of which will involve a complete revolution in the manufacture of cyanogen compounds. But few chemical industries have been pursued for a long series of years with such slight changes in the essential features of the process as has been the case with the manufacture of ferro-cyanide of potassium or yellow prussiate. The primitive method of fusing together potash, iron, and refuse animal matter rich in nitrogen, with its attendant enormous losses of this last important constituent, is still universal. The above-mentioned utilization of the refuse of gas works is still too limited to be brought into serious consideration, and as Europe and America require annually about 50,000,000 kilos of prussiate, it is naturally impossible to look upon this source as in any way sufficient to meet the demands of commerce. Although no practical changes have been made in the manufacture, it has not been for lack of experimental efforts. Numberless attempts have been made to utilize the nitrogen of the air by passing it over carbon and either potash or baryta, etc. Gelis in 1860 proposed a process involving the formation of sulpho-cyanide of ammonium by the action of bisulphide of carbon on sulphide of ammonium, the transformation of this salt into the corresponding salt of potassium, and the change of the latter into the ferro-cyanide by fusion with iron. Notwithstanding experiments carried on until 1870, he was unable to bring any of these three principal steps in the process to the degree of perfection requisite for its technical application.

Tcherniac's process for producing ferro-cyanide of potassium.

The old process.

Gelis's process.

Tcherniac, while retaining the general features of Gelis's process, has introduced new methods for the attainment of the objects sought in the different steps of it, which by their simplicity and effectiveness render the process as a whole capable of practical realization. The following is the succession of the reactions: For the manufacture of sulpho-cyanide of ammonium it is simply necessary to heat together in strong autoclaves bisulphide of carbon and watery solution of ammonia. Under proper conditions nearly the entire amount of bisulphide and ammonia is changed into sulpho-carbonate of ammonium, which decomposes at 100° C. into sulpho-cyanide of ammonium and sulphreted hydrogen—

Tcherniac's process described.

Succession of the reactions.

$$CS_2+2NH_3=CS\left\{\begin{matrix}NH_2\\SNH_4\end{matrix}\right\}=NH_4SCN+H_2S.$$

The evolved sulphureted hydrogen is burned and the sulphurous acid resulting from its combustion is utilized.

Cyanides.

Tcherniac's process of producing ferro-cyanide of potassium.

In order to change the sulpho-cyanide of ammonium into the corresponding potassium salt, lime is added to the solution, and on boiling it half of the ammonia originally taken is regenerated and ready for use again. The proper amount of sulphate of potassium is next added to the solution of sulpho-cyanide of calcium, and the solution of sulpho-cyanide of potassium filtered from the precipitate of sulphate of calcium—

$$2NH_4SCN + CaO = Ca(SCN)_2 + 2NH_3 + H_2O;$$

$$Ca(SCN)_2 + K_2S'O_4 = 2KSCN + CaSO_4.$$

The solution is evaporated to dryness and the salt entirely freed from water by fusion to 200° C. In this condition it is intimately mixed with finely divided iron and maintained for a short time at a dull red heat in closed vessels. On lixiviating the cold mass of cyanide and sulphide yielded by this fusion, the formation of prussiate takes place immediately—

$$6KSCN + 6Fe = 6KCN + 6FeS = K_2S + 5FeS + K_4Fe(CN)_6.$$

The solution of prussiate thus obtained contains a trace of impurities from the presence of a double sulphide of iron and potassium, which is removed by recrystallization. The product then obtained is chemically pure. An all important factor of this transformation of sulpho-cyanide into ferro-cyanide is the character of the iron used. That now in actual use in M. Tcherniac's works is prepared from the residues of the pyrites burners in sulphuric acid manufacture. These residues, as obtained from the French works at a price but little above that of transportation, contain about 95 per cent. of sesquioxide of iron and 5 per cent. of impurities. They are mixed with an excess of powdered coal (ordinary coal slack or dust answers admirably) and heated in a specially adapted furnace in direct contact with a strong reducing flame. After remaining the requisite time in the furnace the oxide of iron is completely reduced to the metallic state—

Peculiar character of iron employed.

$$Fe_2O_3 + 3C = 2Fe + 3CO,$$

which is then raked into air-tight receptacles. After cooling it presents a grayish porous mass, crumbling between the fingers, and well adapted for a variety of purposes in other branches of chemical industry. In the works near Paris, where this process is being introduced, a ton of iron a day is prepared by the above-mentioned method at a cost far below that of cast iron.

In the preparation of red prussiate no material change is

to be noted. It is proposed to substitute bromine for chlorine in the oxidation of the yellow prussiate, since the price of bromine has fallen to so low a figure. *Cyanides.* Red prussiate of iron.

ORGANIC ACIDS. *Organic acids.*

Oxalic acid. Oxalic acid.

Thorn, who has made an exhaustive study of the entire process of manufacturing oxalic acid from sawdust, finds that the best results economically are obtained by using 50 parts of pine sawdust to 40 parts of caustic potash and 60 parts of caustic soda, in the form of a solution marking 42° B. The mixture should be heated in thin layers on iron plates, and a fusion of the mass avoided. The yield of crystallized oxalic acid is 80 per cent. of the weight of wood employed. Cellulose gives better results than lignose, and bran possesses no advantage over wood. Bohlig prepares oxalic acid by adding sawdust to a boiling solution of caustic potash at 36° B. until the mass becomes thick. It is then heated for several hours, when it presents a brown fluid, to which, on cooling, enough water is added to form a solution of 40° B. The oxalate of potassium which crystallizes is changed into oxalate of magnesium, and the pure acid is precipitated from the solution by the addition of hydrochloric acid. Asselin has introduced a new method at St. Denis, in which he makes use of the nitrates in the waste pickle of brass and copper works. These are brought in contact with cheap starchy substances. By the action of the free nitric acid, oxalic acid is produced. This forming a precipitate of oxalate of copper with the nitrates present liberates new quantities of nitric acid to continue the decomposition, which is maintained until the supply of nitrates is exhausted. The oxalic acid is separated from the precipitate of oxalate of copper by means of sulphuric acid. This process affords an ingenious application of waste product otherwise entirely lost. Process of manufacture. Asselin's process.

The use of oxalic acid in beet-root sugar manufacture is becoming greatly extended. Its addition is found to insure a regular ebullition during the boiling of the concentrated juice. The generally received belief in the poisonous properties of oxalic acid has recently been shown by a German chemist to be unfounded. Use in beet-root sugar manufacture. As to the poisonous quality of oxalic acid.

Benzoic acid. Benzoic acid.

This acid is produced at present entirely from naphthalene or from the urine of herbiverous animals. One establish-

Organic acids.

ment in Eastern Germany uses annually 1,200,000 kilos of the latter substance, producing therefrom 3,500 kilos of benzoic acid. Daubin has recently commenced to utilize the quantities of liquid obtained from the slaughter-houses of Paris, which are calculated to yield annually 4,500 kilos of acid. In order to avoid the unpleasant features of this manufacture, *i. e.*, the evaporation of the urine, Putz precipitates directly the hippuric acid as hippurate of iron with perchloride of iron, brings the acid into the form of the calcium salt in solution, and precipitates it with hydrochloric acid. An analogous method is in use in Paris.

Benzoic acid. Daubin's process.

Tartaric acid.

Tartaric acid.

This acid is now obtained in large quantities from the lees of wine, which after pressing contain usually 10 per cent. of tartrates. One house in Vienna manufactures at present 200,000 kilos of tartaric acid from this source alone. Dietrich has introduced the following method for decomposing tartar in order to save the potash present. The tartar is mixed with chalk and heated with water under pressure. At first tartrate of calcium and bitartrate of potassium are formed—

Dietrich's method.

$$2C_4H_5KO_6+CaOCO_3=C_4H_4CaO_6+C_4H_4K_2O_6+CO_2+H_2O.$$

By the solution of the carbonic acid under pressure the chalk is dissolved and acts further on the potash salt—

$$C_4H_4K_2O_6+CaCO_3+CO_2+H_2O=C_4H_4CaO_6+2KHCO_3.$$

The final products are tartrate of calcium and bicarbonate of potassium.

Platinum, iridium, palladium, osmium, etc.

PLATINUM, IRIDIUM, PALLADIUM, OSMIUM, ETC.

The magnificent exhibits of platinum and allied metals and their preparations of Johnson, Matthey, & Co., on account of their magnitude, value, beauty, excellence of workmanship, and their exceptional character in almost every respect, merit more than a passing notice, and through the kindness of Mr. Sellon the following short account is reproduced:

Johnson, Matthey, & Co.

Sellon's account.

"From the year 1800 to 1809 a relative of a present member of this eminent firm was employed in working upon platinum, and discovered the process for its treatment and consolidation, which, generally known as the process of Wollaston, has been until late years in use here, and up to the present time on the Continent. The first apparatus of platinum ever made for the concentration of sulphuric acid was completed in December, 1809, and was supplied to some works now existing near London. The weight of platinum used in this apparatus was 423 ounces.

"The work of this firm in connection with this valuable metal may be summed up under the following heads: *Platinum, iridium, palladium, osmium, etc.*

"The metallurgy of platinum.

"The separation and production in a state of purity of the metals, rare and precious, of which the native ore chiefly consists, viz: Platinum, ruthenium, iridium, rhodium, osmium, palladium, large quantities of which are now in the Exhibition in a state of great purity. Separation and purification of the metals.

"The fusion of platinum Platinum fusing.

by the process first commercially brought to notice by MM. H. St. Claire Deville and Debray in about the year 1856. By the fusion of pure sponge platinum (instead of its simple compression, uniting it by forging under the old system, which must always produce metal more or less porous) it is obtained in a condition of the most perfect compactness, strength, and durability, and of increased resistance to the action of acid. Messrs. Johnson, Matthey, & Co. melt ingots of pure platinum of any weight up to 10,000 ounces.

"The patent autogenous soldering Autogeneous soldering.

(*i. e.*, the joining together of platinum by means of the oxy-hydrogen blowpipe). Experiments with a view to carry out this process were begun in the year 1859, perfected in 1830, and have since been adopted by the firm for all important work. The boilers, etc., shown in the London Exhibition of 1862 were all manufactured upon this system. It is manifestly more advantageous that the whole should be equally durable and uniformly of the same metal, without the inequalities and disadvantages which do and must always exist with gold soldering. The absolute perfection and superiority of this process over the old method have been proved by the results of working more than 160 concentrating boilers, of capacities varying from 20 to 180 gallons. By the old system of working up a still from one piece of metal (which is, however, only practicable with small sizes), that portion of the apparatus which requires most strength, the bottom and lower portion of the sides, is necessarily the thinnest, whereas the dome and upper portion of the sides, where least strength is necessary, becomes the thickest, thus causing an absolutely useless and detrimental waste of metal. When under the old system gold-soldered joints are used for the larger-sized vessels, this evil is only partially mitigated, whilst the use of gold involves extra and useless cost to the purchaser, who has to pay not only for the gold employed at three times the price of platinum, but also for the double thickness of that metal where unnecessary, without in the smallest degree adding to the durability or effective working of the apparatus. The new system is therefore based upon true metallurgical principles, the whole of the apparatus being rendered more perfect and solid than by the old process, with the great advantage of the thickness of metal being regulated in accordance with the relative wear and tear of its various parts.

"Apparatus for the concentration of sulphuric acid. Sulphuric acid concentration apparatus.

"The first sulphuric acid still, made in 1809, was of a deep circular form, and was worked under a leaden chamber. Since that time boilers and pans of different sizes, some entirely of platinum and some with leaden hoods, were in use up to the year 1855, the principle being

Platinum, iridium, palladium, osmium, etc.

Sulphuric acid concentration still of Johnson, Matthey, & Co.

to have a deep layer of acid, digested for a considerable time. In 1855 Messrs. Johnson, Matthey, & Co. showed in the Paris Exhibition a still constructed upon the principle of running through in a continuous stream a shallow layer of acid of about two inches in depth, the drawing for which had been prepared by the eminent chemical engineer, Mr. W. Petrie. In 1862 they again exhibited an improved apparatus on the same general principles, but with an arrangement by which the acid was drawn from a compartment in the center of the vessel, by a tube connected through its side with the cooler.

"A writer in a German contemporary remarks that this process of working with corrugated rectangular boilers has had astonishingly favorable results. The flat layer of acid sliding on the corrugated surface is forced, by the effect of the partitions placed in the vase, a little above the bottom, and produces thus a continual concentration at 66° full, which in the other known systems does not take place in the great generality. By the employment of this new system there is said to be an economy of 50 per cent. in the first saving of platinum, of 70 per cent. in the cost of attendance and general labor, and 48 per cent. in the consumption of fuel.

Advantages.

Alloys of platinum.

"*Alloys of platinum.*

"The preparation of the alloys of platinum of this firm, especially of the alloy with 10 per cent. of iridium, demand special attention. They show a meter rule in course of construction by the system of 'planing' instead of the method of drawing through plates, being the most effectual for obtaining mathematical exactness of shape and perfect purity. They also show a finished kilo standard weight, of the density 21.52.

Planed meter rule.

Exhibits.

"*Exhibits.*

Pyrometer, alembic, assay apparatus, etc.

"The following also deserve attention: Platinum and gold pyrometer to determine the degree of heat in the boiler; laboratory alembic for making hydrofluoric acid, etc.; platinum assay apparatus; square and round platinum serpentines of extraordinary workmanship, shown as specimens of the perfection of autogenous soldering; platinum tube, 500 centimeters long, in one piece, diameter 0.05^{mm}; palladium tube and ingot; pure palladium mass, weight 65¼ kilos, value 260,000 frs. (£10,400), extracted from about 125,000,000 frs. worth of native platinum and gold; pure palladium disk, in which nearly a thousand times its volume of hydrogen gas has been occluded. This volume of gas would be represented by a column nearly 2,000^{mm} high, and 100^{mm} diameter. Original diameter of flat disk of metal, 100^{mm}; diameter after the charging of gas, 102.5^{mm}, the concavity having been caused simply by the absorption of gas; original thickness, 2^{mm}; thickness afterwards, 2.2^{mm}; original weight, 187.3775 grms.; weight afterwards, 188.2882 grms. Platiniferous metals, viz: Pure ruthenium, 2 kilos (compressed ingot), value 40,000 frs.; pure rhodium, 2 kilos (melted ingot); pure osmium, 2 kilos; pure iridium, 2 kilos (melted); pure palladium, 2 kilos (forged ingot); fine wires of the metals gold, platinum, palladium, silver, copper, iron, aluminum, each of 0.001 in. = 0.025^{mm} diameter, 1 kilometer of each, weighing as under:

Palladium disk with occluded hydrogen gas.

Platiniferous metals:
Ruthenium.
Rhodium.
Osmium.
Iridium.
Palladium.

	Grms.
Gold	18.66
Platinum	20.0
Silver	10.16
Copper	8.50

	Grms.	*Platinum and platiniferous metals.*
Palladium	15.50	
Aluminum	3.0	
Iron	7.0	

"The rare metallic preparations exhibited include osmic acid, hyporuthenic acid, platino-cyanide of magnesium, sodio-chloride of rhodium, etc."

Uses of these metals.

The uses of platinum, palladium, iridium, osmium, are not very numerous nor of great extent, but some are of great importance and all are of interest.

As a film for covering objects.

Platinum in a state of extreme division resulting from the reduction of the bichloride of the metal is employed with good effect to cover various objects with a thin, inalterable film, which serves to protect them from the influence of atmospheric agencies, and also to produce certain chromatic effects.

Modes of coating metallic objects.

Several methods are employed for coating metallic objects; for example, by rubbing the surface of the article to be coated with a mixture of a chloro-platinate and tartar, by boiling the objects in a solution of platinum salt, or by means of galvano-plasty.

Solutions employed.

The liquids usually employed are a mixture of bichloride of platinum and of common salt or of the bichloride with organic matters, and the solutions are rendered slightly alkaline.

Böttger's process.

The process suggested by Böttger seems to be the most practical and is the one generally employed. It consists of a solution of bichloride of platinum to which carbonate of soda is added until effervescence ceases. To this solution a little glucose (starch sugar) is added; the whole is then mixed with a solution of chloride of sodium.

Platinizing.

Small objects may be platinized by placing them in a zinc basket and plunging them for a few moments with the solution heated to 140° Fahr., and afterwards well washed and dried in saw-dust.

Indelible ink for zinc labels.

The following mixture forms an indelible ink for writing on zinc labels:

Chloride of platinum	10 grains.
Gum arabic	10 grains.
Pure water	2 fluid drams.

On writing on bright zinc surfaces with a quill pen this ink produces velvety black traces which are as enduring as the plate itself. Platinum is used for the production of certain colors in the decoration of porcelain, *faïence*, and fine earthenware. For this purpose a solution of chloride of platinum in alcohol, to which a little oil of lavender is after-

Enamel colors for porcelain.

Platinum and platiniferous metals.

wards added, is evenly laid on the porcelain surface by means of a camel's-hair pencil, after which the object is exposed to the furnace.

Platinized vessels.

It is claimed that porcelain and glass vessels heavily coated with platinum may successfully replace for many purposes the more expensive vessels of the solid metal.

Platinized mirrors.

This metal is stated to be extensively used for the backing of plate-glass for mirrors, as well also as for making single image mirrors, which is done by depositing the platinum on the front surface of the glass; the metal goes on with a brilliant surface, little inferior in reflecting power or "whiteness" to silver.

Ornamentation of "*articles de Paris.*"

Many of the knick-knacks known as "*articles de Paris*" are ornamented with this metal, such as buttons, jewelry, etc.

Use in photography.

Inalterable photographs on porcelain are made by treating the silver photograph with a solution of bichloride of platinum; the chloride of silver resulting from the action is carefully washed out, and the image is transferred to the porcelain surface, where it is fixed by fusing the metal into the enamel.

Alloys of platinum.

Many alloys of platinum with other metals have been made, the most important of which appears to be that con-

Platino-iridium. 90 10

sisting of 90 parts of platinum and 10 parts of iridium, which possesses properties so remarkable that it has been adopted as the material for the construction of the standard meter furnished to the various governments by the French Commission. This alloy is very hard, elastic as steel, and quite inalterable by atmospheric gases or vapors. In the process

Étalon metre.

of making the *étalon metre* it is absolutely necessary to obtain a mass of the alloy of uniform density and perfect homogeneity; for this purpose the metals are fused by

Oxyhydrogen blow-pipe furnace.

means of a series of oxyhydrogen blow-pipes nicely fitted into a furnace entirely constructed of limestone. A handsome model of this furnace with the compound blow-pipes attached, capable of fusing at one heat an ingot weighing 500 lbs., is exhibited by the *Commission du Metre.*

Uses of palladium.

The associated platinum metals have found limited applications in the arts. Palladium has been employed in the form of alloys for the points of pencils, lancets, as a substitute for gold in dental plates, and especially for the fabrication of the graduated scales of physical instruments, notably those used for astronomical purposes. This metal is well adapted for this purpose on account of its inalterability and its color, which is very similar to that of silver. Its high price, however, has restricted its use very much.

Palladium.

The curious property which palladium possesses of absorbing hydrogen in large quantity was first observed and described by Graham, and excited great interest among scientific men on account of the additional proof it affords of the metallic nature of that gas. Johnson, Matthey, & Co. exhibited a disk of the metal in which a thousand times its volume of hydrogen is occluded. (See page 66.)

Absorption of hydrogen.

Uses of iridium.

Iridium is employed in porcelain painting for producing fine blacks and grays, its sesquioxide being used without the slightest inconvenience with other vitreous pigments. The metal in the shape of wire and plate is used for the electrodes of galvanic batteries.

Uses of iridosmium.

The natural alloy of osmium and iridium has long been used for pointing metallic pens and for the purpose of forming the points and surfaces of suspension of marine compasses, for which it is peculiarly adapted on account of its inalterability, its hardness, its freedom from elasticity, and magnetic qualities. On account of their variety and the difficulties attending their preparation, rhodium and ruthenium have not been applied to any useful purposes in the arts.

ARTIFICIAL FLAVORING EXTRACTS.

Artificial flavoring extracts.

An exceedingly novel and interesting branch of manufacture is that of artificial vanilla, introduced within four years into France and Germany. The source of this favorite flavoring extract has hitherto been Mexico, the West Indies, South America, Java, and Mauritius, where the pods of the vanilla plant are carefully dried and prepared for export. The best sorts of vanilla pods occurring in commerce contain usually from 1.5 to 2.5 per cent. of the aromatic principle vanillin, to which the vanilla owes entirely its taste and odor. The annual consumption of vanilla is about 5,000 kilos in the United States and 30,000 kilos in France, from which figures it is evident that but a few thousand kilos of vanilla would be required to satisfy the present demand for this flavoring matter. The manufacture of the artificial vanillin, as conducted at present, uses as raw product the coniferin, a glucoside occurring in the cambial secretion of all coniferous plants, and obtained in Germany chiefly from the red and white firs found abundantly in the Black Forest and Thuringia. The bark is stripped from the trees early in spring, and, by means of fragments of glass or knives, the sap and a portion of the soft bast are scraped off and collected in vessels. On account of its readiness to undergo

Sources of vanilla.

Percentage of vanillin.

Consumption.

Artificial vanilla from coniferin.

Artificial flavoring extracts.

fermentation, the sap is filtered at once from the bast, boiled for a short time, and then filtered from the albuminous matter coagulated by the heat. The filtrate is evaporated to a fifth of its volume, and then allowed to crystallize. By this means 100 liters of sap yield from ½ to 1 kilo of crystallized coniferin. This is oxidized with the familiar mixture of sulphuric acid and bichromate of potassium, and the vanillin formed thereby extracted with ether or by a current of steam. Complete purification from the vanillic acid formed at the same time is attained by taking advantage of the aldehyde nature of vanillin, and separating it in the form of the sodium bisulphite compound. After being set at liberty from this compound, vanillin is obtained in the form of a white crystalline powder, melting at 81° C.; 20 grams of which correspond to a kilo of the best vanilla. This manufacture is the result of a valuable research on coniferin carried out in the laboratory of Professor Hofmann, at Berlin, by Haarmann and Tiemann in 1873. From their investigations it was shown that coniferin was a glucoside capable of being formed by the union of glucose and coniferyl alcohol under elimination of water, or of being resolved into these substances by the action of emulsin or dilute acids—

Preparation of artificial vanilla.

Haarmann & Tiemann.

Formula of vanillin.

$$\text{Coniferin} + \text{water} = \text{glucose} + \text{coniferyl alcohol};$$

$$C_{16}H_{22}O_8 + H_2O = C_6H_{12}O_6 + C_{10}H_{12}O_3.$$

Both coniferin and coniferyl alcohol yield on oxidation vanillin, $C_8H_8O_3$, or methyl-protocatechuic aldehyde—.

$$C_6H_3 \begin{cases} OCH_3 \\ OH \\ COH, \end{cases}$$

the name assigned to this compound in accordance with the nomenclature accepted at present, and based on very exact analytical decompositions.

The establishment of the above comparatively simple formula of vanillin, and of its exact position in the series of aromatic compounds, has naturally incited other efforts to prepare this valuable principle from other closely allied bodies. Of these attempts two have been successful. The methods, although patented, are still too costly to permit of competition with that just described.

Reimer's method.

The first of these was discovered by Reimer, in 1876, and is based on a most important reaction due to this chemist, viz, the introduction of the aldehyde group CHO in phenols by the action of chloroform in presence of alkalies. Thus,

ordinary phenol—C_6H_5OH—yields salicylic aldehyde, $C_6H_4\begin{cases}OH\\CHO.\end{cases}$ In like manner guaiacol, or methyl-pyrocatechin, $C_6H_4\begin{cases}OCH_3\\OH\end{cases}$—one of the constituents of beech-tar creosote—is changed by the action of chloroform into the corresponding aldehyde, *i. e.*, vanillin— *Artificial flavoring extracts.* Vanillin.

$$C_6H_3\begin{cases}OCH_3\\OH\\CHO.\end{cases}$$

The second method, discovered by Tiemann, is based on the oxidation of the eugenol contained in oil of cloves, oil of pimento, and other volatile oils, a colorless aromatic liquid closely allied to the coniferyl alcohol mentioned above— Tiemann's method.

$$\text{Eugenol} = C_6H_3\begin{cases}OCH_3\\OH\\C_3H_5\end{cases};\ \text{coniferyl alcohol} = C_6H_3\begin{cases}OCH_3\\OH\\C_3H_4OH.\end{cases}$$

It consists in the extraction and purification of the eugenol in oil of cloves; introduction of the acetyl group by treatment with acetic anhydride; oxidation of the aceto-eugenol thus formed with potassium permanganate; elimination of the acetyl group from the resultant aceto-vanillin by means of weak alkalies; and extraction of the pure vanillin with ether.

The above reactions and operations, based on elaborate and minute researches, show in a striking manner the dependence of industrial chemistry on the so frequently derided theoretical investigations of the modern chemical laboratory.

Rump found, in 1878, vanillin in Siamese benzoin resin, and separated it from the residual liquors after the treatment with lime for the separation of the benzoic acid In the same year E. Serullas, of Paris, has extracted from the pericarp of oats an essential principle to which he gives the name *aveneine*, and obtained vanillin from this body by the ordinary methods of oxidation. Rump's method. Serullas' method.

OZOKERIT. *Ozokerit.*

Ozokerit is found in small quantities at Binney Quarry, Linlithgowshire, in Wales, and in coal mines near Newcastle. It is chiefly obtained, however, from Galicia, where it occurs in connection with petroleum springs in the blue clay of the Sources of ozokerit.

Ozokerit.

Sources of.

miocene formation, principally in Borislav, near Drohobycz, and Dzwiniacz, near Stanistawow, at the northern foot of the Carpathian Mountains, and at Swätoi-Ostrow, an island in the Caspian Sea. In 1875 about 20,000,000 kilos were mined, of which eight-ninths came from Borislav alone.

Character.

Native ozokerit of the best quality is translucent, of a honey-yellow color, and about as hard as common beeswax. It is sometimes found in lumps and layers from 1 to 3 ft. in thickness, weighing several hundredweights. More frequently, however, it occurs in thin layers and small pieces, which must be separated from associated minerals. The smallest pieces are obtained by a process of washing. The poorer qualities are highly colored, often quite black, and are either too soft, from incorporated petroleum, or too hard, like asphalt; are mainly used for the production of paraffine.

Used for manufacture of ceresine and paraffine.

The best yellow qualities are used for the manufacture of "ceresine," a factitious "wax," which is largely exported as beeswax. In making paraffine from ozokerit, which yields on an average of 42 per cent., according to the quality of the mineral, the crude hydrocarbon is first melted and drawn off; the residue boiled with water to recover the last portions remaining in the partially exhausted mass; the whole allowed to stand for several hours for any suspended matters to settle out, and the fused hydrocarbon poured into molds, which contain 100 to 120 lbs. It is shipped without further preparation to Vienna, Paris, London, and other places, where it is further purified and converted into beeswax, illuminating oils, and paraffine.

Process.

Manufacture of paraffine.

The manufacture of paraffine is effected by distillation over direct fire, from flat-bottomed iron retorts holding 1,500 to 2,000 lbs., the products of such working being—

	Per cent.
Benzine	2 to 8
Naphtha	15 to 20
Paraffine	36 to 50
Heavy lubricating oils	15 to 20
Coke	10 to 20

The paraffine is pressed, treated with sulphuric acid and caustic soda, filtered through paper and fine animal charcoal, and manufactured into candles. (GRABOWSKY).

EXHIBITORS OF CHEMICAL PRODUCTS.

AUSTRIA-HUNGARY.

Chemical industries behind those of France, Germany, and Britain.

The chemical industries of this empire still rests behind those of France, Germany, and Great Britain, and are far from attaining a relation commensurate with the extent of the country and its natural wealth in natural products. A few of the leading establishments are fully abreast of the nations in the rapid march of improvement in chemical technology; many of them, however, retain methods and processes long since discarded in Western Europe. Apart form a number of small establishments for the production of tartar and potash, Austria contains 85 chemical works, situated chiefly in Bohemia, Silesia, and lower Austria. The apparently unlimited supplies of salt and pyrites of iron form the basis of most of these manufacturing interests. While more than exceeding the home demand for sulphuric and other acids, Austria's alkali production is still insufficient, and the deficiency is met by importation mainly from England.

Eighty-five chemical works in Bohemia, Silesia, and lower Austria.

Localities and statistics of the chief chemical products.

The chief products, according to statistics taken from the census of 1870—since which time there has been a notable increase in many branches—are: Sulphuric acid, annual production, over 40,000,000 kilos; seats of thisindustry being at or in the neighborhood of the following places: Vienna, Voralberg, Silesia, Würbenthal, Hruschau, Petrowitz, Bohemia, Aussig, Prague, Kasnau, Kralup, etc. Nordhausen sulphuric acid is produced at the establishment of Stark, in Bohemia, to the amount of 1,720,000 kilos per annum; hydrochloric acid, 30,000,000 kilos; nitric acid, 3,000,000 kilos; sulphate of soda, 16,946,500 kilos; soda crystals, 3,221,600 kilos; calcined soda, 7,291,100 kilos, in Bohemia and Silesia; bicarbonate of soda, 234,400 kilos; caustic soda, 526,000 kilos; caustic soda-lye, 66,000 kilos; chloride of lime, 1,400,000 kilos; nitrate of potash, 1,050,000 kilos, and nitrate of soda, 5,600 kilos, in Simmering, Hrastning, Prague, Carolinenthal, Welwarn, and Triest; yellow prussiate of potash, 470,000 kilos, in Brünn, Drozdov, and Vienna; arseniate of potassium, 5,600 kilos; bichromate of potass., 112,000; sulphate and hydrochlorate of ammonia, 210,000 kilos; hyposulphite of ammonia, 43,000 kilos; hyposulphite of soda, 75,000 kilos; sulphate of magnesia, 16,800 kilos; acetate of lead, 590,000 kilos; acetate of iron, 101,000 kilos; acetate of alumina, 33,000 kilos; acetate of calcium, 30,000 kilos; acetate of sodium, 672 kilos; sulphate of copper, 65,000 kilos; sul-

AUSTRIA-HUNGARY.

phate of zinc, 8,000 kilos; ammonia alum, 56,000 kilos; nitrate of iron, 560 kilos; mercury salts, 3,360 kilos; tin salts, 106,000 kilos; nitrate of zinc, 840 kilos; tartrate of potassium, 218,000 kilos; double tartrate of sodium and potassium, 9,800 kilos; tartaric acid, 23,000 kilos.

Austria's chemical products.

At present Austria imports 6,765,000 kilos of sulphur; 4,737,000 kilos of nitrate of soda; 11,870,800 kilos of carbonate of soda in various forms; 668,100 kilos of sulphate and bisulphate of soda; 2,158,600 kilos of chloride of potassium; 1,971,000 kilos of chloride of lime; and 403,900 kilos of caustic soda.

Chemical works of the Empire.

The most important chemical works of the Austrian Empire represented were:

Oesterreicher Verein für Chymische und Metallurgische.

Oesterreicher Verein für Chymische und Metallurgische Production, Aussig and Kralup, Dr. Max Schaffner, director, well known by his method for the regeneration of sulphur:

Dr. Max Schaffner.

This establishment, which is the most extensive of the Austrian soda works, and one of the most complete in Europe, exhibited all the products of the soda industry. The annual production of this company is:

Annual production.

	Kilos.
Sulphuric acid	17,500,000
Crude sulphate of soda	15,000,000
Crystallized sulphate of soda	500,000
Calcined soda	6,250,000
Soda crystals	3,000,000
Caustic soda	1,500,000
Hydrochloric acid	21,750,000
Chloride of lime	2,500,000
Nitric acid	1,500,000
Superphosphates	2,500,000
Hyposulphite of soda	500,000
Sulphur, recovered from residues	1,000,000
Bicarbonate of soda	400,000
Chlorate of potash	50,000
Chloride of barium	500,000
Sulphide of sodium	400,000

The establishment was founded in 1857, has a capital of $2,500,000, and the value of its annual productions amounts to $1,500,000; 2,000 workmen, and engines with 500-horse power, find occupation here. Large quantities of thallium are obtained as a by-product from the Westphalian pyrites used. The exhibits included a fine model of the tower employed for the condensation of the hydrochloric acid.

Wagenmann, Seybel, & Co., Vienna.

Wagenmann, Seybel, & Co., Vienna: Works founded in 1828; employ 200 workmen. This manufactory possesses six series of vitriol chambers, with three of which pyrites are used; with two, Sycilian sulphur; and with one, sulphur regenerated by Laming's method. In the latter process pru-

AUSTRIA-HUNGARY.

siate of potash and ammonia salts are prepared from the mass before it is roasted. The yearly production is 7,000,000 kilos of sulphuric acid. Four platinum stills, representing a value of $50,000, are used for the concentration of the acid. From the Vienna gas-waters the establishment prepares yearly 100,000 kilos of caustic ammonia and 300,000 kilos of ammonia salts; from the treatment of Styrian spathic iron with sulphuric acid, 300,000 kilos of ferrous sulphate, and, in addition, 1,500,000 kilos of hydrochloric acid, 1,500,000 kilos of nitric acid, 40,000 kilos of tin salts, 60,000 kilos of sulphate of copper, 75,000 kilos of acetate of lead, etc. An important article in the list of the products of this manufactory is tartaric acid, prepared from the pressed and dried lees of wine, an industry created mainly by the researches and efforts of E. Seybel. The annual production of this substance is 224,000 kilos, most of which is exported to Russia.

Chemical works.

Wagenmann, Seybel, & Co.

L. Köller, Brünn.

L. Köller, Brünn: This manufacturer makes a specialty of tartaric acid and its salts. His exhibit was tartrate of calcium.

F. C. Schwab, Pettau.

F. C. Schwab, Pettau: Refiner of sulphur and saltpeter. Annual production 400,000 kilos of refined sulphur, and 60,000 kilos of saltpeter.

Consorzio delle Saline di Pirano, Istria.

Consorzio delle Saline di Pirano, Istria: Crude and refined salts obtained from sea-water, bromine, chloride of lime, sulphate of soda, and sulphuric acid. Value of annual production, $50,000.

B. Margulies & Co., Vienna.

B. Margulies & Co., Vienna: Ammonia and its salts and saltpeter.

Committee of Upper Austria.

Committee of Upper Austria, Iodbad Hall: Salts of iodine.

Imp. Dept. of Agric.

Imperial Department of Agriculture, Vienna: Uranium salts.

Imp. Dept. of Mines.

Imperial Department of Mines, Vienna: Mercury, cinnabar, salts of uranium and of vanadium.

Casaoni & Calatta, Val di Ledro.

Cassoni & Calatta, Val di Ledro: Magnesia and salts of magnesia.

Soc. des Chemins de Fer de l'État.

Sociétés des Chemins de Fer de l'État: The establishments of the company in Moldova, Hungary, exhibited sulphuric acid, sulphates of soda and copper. The annual capacity of the sulphuric acid works is 1,500,000 kilos; 30,000 kilos of sulphate of soda are manufactured from nitrate of soda. The yearly yield of sulphate of copper is 207,000 kilos, and 263 kilos of silver are obtained from the argentiferous residues of the manufacture.

Soc. Hongroise pour Lava.o des Laines, B'a-Pest.

Société Hongroise pour le Lavage des Laines, Buda-Pest. Exhibited potash obtained from suint of wool. Cream of

tartar was exhibited by a number of Hungarian establishments.

BELGIUM.

BELGIUM.

Chemical works.

In Belgium, notwithstanding its vast deposits of coal, the various chemical industries occupy a comparatively subordinate position. The establishments, although numerically few, are still, individually, of considerable extent, and the latest improvements in technical methods are in full operation. The annual production of sulphuric acid is about 30,000,000 kilos. The soda industry, so important to the extensive glass manufactures of Belgium, stands at a high point of perfection. The leading exhibit was naturally that of—

Numerically few, but of considerable extent.

Solvay & Co., Couillet.

Ernest Solvay & Co., of Couillet: This establishment, founded in 1865, is the one in which the practicability of the new ammonia-soda process was first successfully demonstated. They sent a fine exhibit of the various products by this method, including hydrochloric acid obtained from the residual chloride of calcium, and a series of plans of apparatus for regenerating the ammonia used in the process. One hundred and ten workmen are employed, and the annual production of soda amounts to 7,500,000 kilos.

Fab. des Produits Chimiques d'Auvelais.

Fabrique des Produits Chimiques d'Auvelais manufactures sulphuric and hydrochloric acids, sulphate of soda, and phosphates. This establishment, founded in 1851, employs 160 workmen, possesess 10 vitriol chambers, and produces annually acid valued at $400,000. It is well known for the enterprise manifested in the introduction of very perfect arrangements for the condensation of the hydrochloric acid vapors.

Soc. Anon. de Bélian.

Société Anonyme de Bélian, Mesvin: Acids, soda, phosphates.

David & Co., Moustier.

David & Co., Moustier: Pure soda salts, especially bisulphite, hyposulphite, sulphydrate, and phosphate of soda.

E. Lannoy, Fils, & Co., Brussels.

E. Lannoy, Fils, & Co., Brussels: Neutral sulphate of alumina.

Koch & Reis, Anvers.

Koch & Reis, Anvers. Exhibited fine specimens of refined sulphur. The establishment was erected in 1868, and employs 80 workmen, who attend 16 furnaces; its annual production is 6,000,000 kilos.

Verzyl & Co., Wilsele.

Verzyl & Co., Wilsele. Exhibited specimens of their saltpeter refined to $\frac{1}{10000}$, and soda manufactured by the ammonia process.

Usines des Moulins, Ghent.

Usines des Moulins, Ghent: Soda and sulphate of soda, chloride of calcium, chloride of lime, sulphuric, nitric, and hydrochloric acids, sulphate of iron, acetic acid, phenol, benzine, nitro-benzine, and salicylic acid.

CANADA.

CANADA.

Various general chemical products were exhibited by J. Davids, Toronto; Lyman Bros. & Co., Toronto; H. J. Rose, Toronto; Lyman, Clare & Co., of Montreal, who showed potashes; and the Chemical Works of Brockville, nitric, sulphuric, and hydrochloric acid.

Chemical works.

DENMARK.

DENMARK.

Denmark was represented by her two principal manufactories:

Chemical works.

Fredens-Mölle, Amac: Established in 1822; employs 225 workmen, and turns out $640,000 worth of products annually, consisting of sulphuric acid and superphosphates.

Fredens-Mölle, Amac.

Hagemann & Jörgensen, Copenhagen: Established in 1856, and gives employment to 80 operatives. Annual production valued at $160,000. This manufactory was the first to extract soda from cryolite coming from the vast deposits in Greenland. At present it uses up 2,000,000 of the 8,000,000 kilos shipped from Arkut. The cryolite used, containing 84 to 88 per cent. of fluoride of aluminum and sodium—AlF_3, 3NaF—yields on heating with carbonate of lime 13 per cent. of alumina and 60 per cent. of soda. This yield is augmented, however, to 13 per cent. of alumina and 70 per cent. of soda by adding a certain amount of fluorspar to the mixture. There are but three other establishments engaged in the cryolite-soda industry, bauxite having taken its place in the five German manufactories, which ten years ago were occupied with this material. The exhibits included soda crystals, hydrate of alumina, fluoride of calcium, sulphate of alumina, and pure cryolite.

Hagemann & Jörgensen, Copenhagen.

Cryolite industry.

Bauxite superseding cryolite.

FRANCE.

FRANCE.

In France nearly every branch of chemical industry is in successful operation and at a well-advanced stage of perfection; a result due to her varied forms of natural wealth, her maritime advantages, and to the fact of having been the cradle of modern chemistry. As the measure of the growth of technical chemistry in this country during the past few years we can take the annual production of sulphuric acid, which has risen from 90,000,000 kilos in 1867 to 150,000,000 kilos in 1877.

Chemical industries highly developed.

Product of sulphuric acid.

The annual production of soda is over 175,000,000 kilos, representing a value of $6,000,000. This, however, is insufficient for the wants of the country, and 11,000,000 kilos are imported from England annually. The number of soda works

Soda, annual production.

Imports.

FRANCE.

Chemical industries.

Kelp industry.

Borax industry.

Ammonia soda.

Sulpho-carbonates for combating phylloxera.

French slow to adopt improved processes.

The French exhibit the most complete and tasteful.

Chemical works.

Bondé & Fils, Marseilles.

B. Cros, Narbonne.

O. Renard, Marseilles.

Deiss & Fils, Paris.

is ninety-six, giving employment to 5,162 operatives and 1,000 horse-power. The amount of salt used in the soda and other works is 120,000,000 kilos annually, and the yearly importation of sulphur is over 40,000,000 kilos. Several branches of chemical industry which have been practically created and perfected in France, notably the preparation of potash salts from the mother-liquors of the salt gardens and the kelp industry, are now battling against severe odds; the one against the natural deposits of potash in Central Europe, the other against the deposits of iodine-bearing salts in Peru. Among the more recently introduced industries should be mentioned that of borax, dating from 1869, the ammonia-soda manufacture, and the preparation of the vast quantities of sulpho-carbonates required to combat the devastating phylloxera.

As a rule the French manufacturers are slow in adopting the improvements so rapidly introduced by their neighbors to the north and the east. As yet none of the labor-saving furnaces of the English soda works have been adopted across the channel, and such improved processes as Weldon's for the regeneration of oxide of manganese, or the use of the Glover tower, have but recently secured a general recognition. The section of chemical products on the French side was among the most complete in the division, and in extent, variety, and tasteful display was unapproached by that of any other nation.

Boudé & Fils, Marseilles: Established in 1850; one of the largest of the French sulphur refineries. They have ten furnaces and condensers, with a daily capacity of production of 14,000 kilos of flowers of sulphur and 8,000 kilos of roll sulphur. Their mills turn out daily 10,000 kilos of ground sulphur. Annual production, 6,500,000 kilos of refined sulphur, being one-fourth of the total amount used in France. The loss of sulphur in the process of refining has decreased from 16 per cent. in 1860 to between 3 and 4 per cent. at present. Thirty to 40 kilos of coal are required for each 100 kilos of refined sulphur.

B. Cros, Narbonne: Factory established in 1856. This is one of the chief establishments for pulverizing the crude sulphur used in the vineyards. The annual production of this work is 2,400,000 kilos of refined and 6,200,000 kilos of pulverized sulphur.

O. Renard, Marseilles. Exhibited handsome specimens of crude and refined sulphur and compounds of it with other substances.

Deiss & Fils, Paris: Established in 1848; exhibited bisul-

FRANCE.

Chemical works.

phide of carbon apparatus for the extraction of oil from the residues of the olive presses, of the candle factories, etc.; cyanide of potassium, chloride of sulphur, sulpho-carbonates of the alkalies. The method of E. Deiss for the manufacture of bisulphide of carbon was introduced thirty years ago, and has brought down the price of this article from $12 to 12 cents the kilo. The present yearly production of 800,000 kilos is consumed almost entirely in the vineyards of France, to combat the army of phylloxera, which seriously threatens the very existence of the vine in that country.

Deiss & Fils, Paris.

Bisulphide of carbon reduced to one-hundredth its former price.

J. Blondel, Marseilles.

J. Blondel, Marseilles: This establishment was founded by Berthollet. Its exhibits consisted of sulphuric and nitric acids, soda, and anhydrous sulphate of soda, in the manufacture of which it is engaged on a large scale.

Cazalis & Leenhardt, Montpellier.

Cazalis & Leenhardt, Montpellier. Manufacture 3,000,000 kilos of sulphuric acid annually from Sicilian sulphur. Besides this product they exhibit bauxite containing 60 per cent. of soluble alumina; tartaric acid (annual production 50,000 kilos); crude salt from the mother-liquors of the salines, extracted by Balard's process, and used for the manufacture of alum; pure alum free from iron and uncombined acid (annual production of pure alum 40,000 kilos and of common alum 80,000 kilos).

Comp. des Salines du Midi, Montpellier.

Compagnie des Salines du Midi, Montpellier: Calcined magnesia and salts obtained from the mother-liquors of salt works.

Comp. Gen. des Chimiques du Midi.

Compagnie Générale des Produits Chimiques du Midi, Marseilles: Soda and oxide of manganese.

Duchemin & Chouillou, Rouen.

Duchemin & Chouillou, Rouen. Exhibited various products of the soda manufacture and specimens of their superphosphates.

Gautier & Mairesse, Pierre-Bénite.

Gautier & Mairesse, Pierre-Bénite: Soda preparations, caustic potash, sulphide of potassium, bichromate of potassa, regenerated from the residues coming from the oxidation of anthracene to anthraquinone in the artificial alizarine manufactures; chloroform, ether, etc.

Soc. Anon. de Croix, Roubaix.

Société Anonyme de Croix, near Roubaix: Salts of potash, caustic potash, etc.

Soc. Anon. des Chimiques (Maletra).

Société Anonyme des Produits Chimiques (Établessements Maletra) was represented by an excellent exhibition of most of the products of the soda industry, caustic soda, the mineral acids, chlorates, sulphate of soda, chloride of manganese, and salts of various other metals. Regeneration of oxide of manganese by Weldon's method was shown by means of diagrams and drawings.

FRANCE.

Chemical works.

Soc. Anon. des Produits Chimiques du Nord, Lille.

C. F. Kuhlmann.

Société Anonyme des Produits Chimiques du Nord, Lille: This famous establishment presented a fine exhibit of all the products connected with the soda industry; oxide of manganese, superphosphates, lead and barium salts. C. F. Kuhlmann, the director and chief proprietor of the extensive works of this company, stands unquestionably at the head of French chemical manufacturers. Since his first discovery, in 1823, of two distinct coloring matters in madder, he has enriched nearly every branch of applied chemistry by his numerous contributions of new facts. It is only necessary to allude to the introduction of the principle of saturation into the manufacture of sugar, the application of crystallization for technical purposes, the methods for saving potash salts in waste products, for producing nitrates and artificial manures, and finally the creation of the baryta industry, which has grown to enormous proportions and is of immense value to France.

Soc. Anon. de Sambre et Meuse, Hautmont.

Statistics of the works and yield.

The apparatus.

Consumption of raw material.

Société Anonyme de Sambre et Meuse, Hautmont: This company was organized in 1857, with a capital of $720,000. Handsome exhibit of all the soda products and numerous superphosphates. The company owns large mines of pyrites at Philippeville, Belgium, which are worked by 70 miners. In the establishment at Hautmont there are 265 operatives; engines of 360 horse-power; 6 vitriol chambers, containing in all 16,000 cubic meters; a platinum evaporator capable of yielding daily 9,000 kilos of sulphuric acid at 66° B.; Thélen's apparatus for evaporating solutions of crude soda; 8 furnaces for the preparation of sulphate of soda, and 4 for converting the sulphate into crude soda. Weldon's method for the regeneration of oxide of manganese is used in these works. The annual consumption of raw material here is:

	Kilos.
Pyrites	7,000,000
Coal	15,000,000
Salt	6,500,000

Annual product.

The annual product is:

	Kilos.
Sulphuric acid, of which 2,000,000 kilos are sold	9,000,000
Ordinary sulphate of soda	6,500,000
Refined sulphate of soda	1,200,000
Hydrochloric acid	10,000,000
Caustic soda	1,000,000
Soda crystals	2,500,000
Salts of soda	1,800,000
Chloride of lime	1,000,000
Sulphur, regenerated	250,000
Superphosphates	1,500,000
Precipitated phosphates	1,000,000

FRANCE.

Société Anonyme des Soudières du Griffon, Marseilles: This company exhibited fine specimens of soda prepared by the ammonia process with Boulevard's apparatus. The annual production of their works is 3,600,000 kilos of soda. The ammonia required to carry out the process is obtained from the Marseilles Gas Works.

Chemical works.

Soc. Anon. des Soudières du Griffon, Marseilles.

L. Thomas & Co., Paris: Exhibit consisted of "Jarel water" (for bleaching purposes), prepared by the reciprocal action of sulphate of soda and chloride of lime in solutions, superphosphates, salts of soda, ammonia, copper, etc., and selenium. A very interesting object in this exhibit was a thin sheet of *gallium* about 8 inches square. It was of a light gray color, and the crystalline appearance of the surface was not unlike that of antimony.

L. Thomas & Co., Paris.

Gallium.

Société des Manufactures des Glaces et des Produits Chimiques de Saint-Gobain, Chauny, and Cirey. Exhibited products of the soda industry, chlorate of potash, alum, etc. This establishment, renowned for its immense and perfect mirrors, has, by union with a firm at Lyon possessing the famous pyrites works of Chessy and St.-Bel, and numerous soda and sulphuric acid factories, attained proportions far surpassing those of any other undertaking in the chemical industries of France. The various works of the company admit of an aggregate daily production of 200,000 kilos of sulphuric acid. The pyrites of St.-Bel are almost pure sulphide of iron, containing less than one per cent. of impurities. The attempt has been made to use the residues for the manufacture of iron by first roasting them with salt and extracting the sulphur and copper present in the form of sulphate of soda and chloride of copper, but is apparently not continued at present.

Soc. des Manuf. des Glaces, etc.

St. Gobain.

Soda and sulphuric acid factories.

Solvay & Co., Varangéville-Dombasle: Established in 1873, and employ 500 operatives. The French branch of this company is conducted on a much larger scale than the Belgian mother establishment, the former producing 20,000,000 kilos of soda annually, the latter but 7,500,000. The exhibit was small and by no means attractive, being confined to soda, chloride of calcium, etc., the simplicity of the process giving no opportunity for the manufacture of the numerous by-products hitherto arising from soda works.

Solvay & Co., Varangéville-Dombasle.

F. Tissier, Finistère: This establishment was the first (1829) to commence the manufacture of iodine from seaweed, and is at present the most important of those engaged in this branch of manufacture. Its annual production of iodine and iodide of potassium amounts to 18,000 kilos, 3,000 kilos of bromine and bromide of potassium. There

F. Tissier, Finistère.

FRANCE.

Chemical works.

was in addition exhibits of other iodides and bromides and nitrate, sulphate, and chloride of potassium.

Carof & Co., Finistère.

Carof & Co., Finistère: This factory was established in 1858, and now produces annually from 260,000 kilos of kelp—

	Kilos.
Chloride of sodium	58,500
Chloride of potassium	55,250
Sulphate of potassium	24,960
Iodine	2,665

This house imports large quantities of bromine for the preparation of bromide of potassium. Exhibit consisted of raw materials of the iodine manufacture and the finished product.

Glaizot Frères, Abervrach.

Glaizot Frères, Abervrach. Employ 12 workmen, and produce annually 1,200,000 kilos of kelp. They exhibited crude and pure iodine, salts of iodine and bromine of very fine quality, and sulphate of potassa.

De Lécluse-Trévoëdal Frères, Audièrne.

De l'Écluse-Trévoédal Frères, Audièrne: This establishment was founded in 1872, and now gives employment to 50 operatives, who annually turn into commerce the following amounts of products:

Annual production.

	Kilos.
Chloride of potassium	300,000
Sulphate of potash	150,000
Chloride of sodium	600,000
Iodine (most of which is converted into iodide of potassium)	10,000
Bromine	1,500

Consumption of raw material.

The annual consumption of raw material is:

	Kilos.
Kelp (for the production and transportation of which 2,500 persons are engaged)	2,000,000
Hydrochloric acid	25,000
Sulphuric acid	25,000
Potash	8,000
Chlorate of potash	2,000
Nitric acid	500
Coal	1,500,000

These figures give a pretty fair representation of the character and extent of the operations in French varech works. This firm displayed a collection of very fine specimens of their products.

Pellieux & Mazé-Launay, Kerhuon.

Pellieux & Mazé-Launay, Kerhuon. Commenced their industry in 1867, and the establishment now obtains 880 kilos of iodine from 84,000 kilos of kelp monthly. They made very interesting exhibits of the divers varieties of varech, classified according to the percentages of iodine contained in them, as well as iodine, bromine, iodides, and potash fertilizers.

FRANCE.

Chemical works.

Paisant & Co., Pont-l'Abbé: In this factory, which was established in 1840, 1,200,000 to 2,000,000 kilos of kelp are changed annually into iodides, bromides, chlorides, and sulphate of potassium and chloride of sodium. Sulphide of potassium is also produced in considerable quantity here for the preparation of sulpho-carbonate of potash, which is sold for use in the vineyards.

Paisant & Co., Pont-l'Abbé.

A. Roques, Paris: Established in 1846, and now gives employment to 30 operatives in the refining of camphor, resublimation of iodine, and the conversion of iodine and bromine into their potassium salts. His annual production is 5,500 kilos resublimed iodine, 30,000 kilos iodide of potassium, 14,000 kilos bromide of potassium, and 235,000 kilos refined camphor. The subliming flasks for the latter substance are made on the premises, and are consumed in immense numbers, since each receptacle can only be used for one operation, and must be broken to release the flat cake of camphor. The exhibit of the products of this house was exceedingly handsome.

A. Roques, Paris.

Camphor, iodine, and bromine.

A. Lefebvre, Corbehem. Exhibited potash and salts of potassium, rubidium, extracted from the residues of the beet-root sugar manufacture, after having first served for the production of alcohol.

A. Lefebvre, Corbehem.

Savary & Co., Nesle. Displayed raw materials and finished products connected with the distillation of beet-root molasses, potash, and salts recovered from the residues.

Savary & Co., Nesle.

E. Porion, Wardrecques: Salts obtained from the residues of the alcohol manufacture; carbonate of potash containing 95 per cent. of pure carbonate.

E. Porion, Wardrecque.

A. Nugues, Saint Saulve-les-Valenciennes: Potash from the beet-root residues; carbonate of potash, 92 per cent. annual production; carbonate of potash, 80,000 kilos; carbonate of soda, 650,000 kilos, together with a considerable amount of chloride of potassium.

E. Nugues, Saint Saulve-les-Valenciennes.

Décle & Co., Rocourt. Exhibited alcohol and by-products. In this establishment the residues calcined yield daily 11,000 kilos of crude salts containing 92 per cent. carbonate of potash and 1½ per cent. of carbonate of soda.

Décle & Co., Rocourt.

Rogelet, Houzeau, & Co., Reims. Had potash and saline matters extracted from suint of wool.

Rogelet, Houzeau & Co., Reims.

C. Desmazures & Co., Maisons-Laffitte: Fabrique established in 1869 with 207 horse-power, and manufacture annually 1,000,000 kilos of borax from Turkish borate of lime. They contributed a very handsome collection of specimens of borax, boracic acid, and borate of manganese, etc.

C. Desmazures & Co., Maisons-Laffitte.

FRANCE.

Chemical works.

Pechiney & Co., Salindres.

Pechiney & Co., Salindres: This establishment was founded in 1855 by H. Merle, one of the most distinguished industrial chemists of France, who died in July, 1877. After the discovery of marvelous deposits at Stassfurth, the very large interests in France involved in the production of potash salts from sea-water by Balard's process were threatened with entire ruin. Merle succeeded, however, after several years assiduous labor and study, in bringing to bear improvements in every stage of the process, and by that means economizing the operations to such a degree as to place the industry on a footing enabling it to compete with the natural deposits. Valuable improvements in the coke towers for the absorption of hydrochloric acid are likewise due to him.

Merle's improvements in the production of potash salts.

Pyrites mines.

The company possesses pyrites mines in Gard and Ardèche, worked by 220 miners and 150 horse-power, raising annually 40,000,000 kilos of pyrites. At Giraud it has extensive salt works, capable of an annual production of 100,000,000 kilos, and an establishment for treating the mother-liquors, which yields annually:

Salt works.

	Kilos.
Sulphate of soda (hydrated)	4,000,000
Sulphate of magnesia	2,000,000
Chloride of potassium	1,200,000

The two are worked by a force of 160 operatives and 150 horse-power.

Works at Salindres.

The works at Salindres employ 950 operatives and possess 300 horse-power. Use is made of the Schaffner-Mond method for the regeneration of sulphur and of Weldon's process for the reviving of the manganese used in the production of chlorine.

Consumption of raw material.

The annual consumption of raw materials is:

	Kilos.
Coal	50,000,000
Pyrites	15,000,000
Salt	15,000,000
Limestone	25,000,000
Fossil phosphates	1,700,000
Chloride of potassium	500,000
Bauxite	500,000

Annual production.

The annual production is:

	Kilos.
Soda	12,000,000
Chloride of lime	2,800,000
Chlorate of potassa	400,000
Phosphate of lime (precipitated)	800,000
Sulphur (regenerated)	600,000
Sulphate of alumina	500,000
Aluminium	1,600
Sodium	6,000

FRANCE.

The exhibition of aluminium was especially noteworthy.

Chemical works.

Aluminium is now made chiefly in France, and only by this establishment, it and the "Société Anonyme de Aluminium" are the most extensive producers of ornamental and other objects from this metal and its alloys. M. Pechiney & Co. exhibited aluminium in blocks, wire, sheets, and foil. The Société Anonyme exposed a great variety of objects, from a thimble and pen-holder to complete dinner sets, of aluminium bronze and of the pure metal. The bronze appears to find more favor with the public than the pure metal, on account, perhaps, of its lower price and beautiful golden color. The prices of some of the articles are as follows: Aluminium bronze tablespoons cost from $2 to $2.50 each; teaspoons from $3 to $5 per dozen; pure aluminium thimbles 25 cents each. A number of small articles made from woven aluminium wire were much admired.

Pechiney & Co., Salindres. Aluminium. Soc. Anon. de Aluminium. Aluminium bronze.

Clermont Fils, Lemaire & Fischer. Exhibited telescopes, opera glasses, and other optical instruments mounted wholly or in part in aluminium. They presented a novel and elegant appearance and were very light. Chemical balances made entirely or in part of this metal were exhibited by A. Collet, which, when loaded with 100 grams on each pan, were sensitive to the 0.1 millegram or one millionth of the load on each pan; the price was 2,000 francs. Johnson, Matthey, & Co., of London, exhibited coins or tokens made of an alloy of 98 parts of aluminium and 2 parts of nickel, which are very light, hard, bright, and not liable to tarnish like silver. This alloy takes and preserves a high polish and very sharp impressions when stamped, and appears well adapted for coinage. An alloy of this metal with silver is said to be used to considerable extent in the manufacture of some varieties of jewelry.

Clermont Fils, Lemaire & Fischer. Optical instruments and balances in aluminium. Johnson, Matthey & Co. Aluminium, 98; nickel, 2.

Société Anonyme des Produits Chimiques pour les Sciences et l'Industrie, Paris: This exhibit was quite interesting, consisting of a large collection of various products, such as thallium salts, uranium salts, urea, gallic acid. Among the very rare compounds were noticed specimens of triphenylmethan and benzophenon, prepared by the new synthetic method of Crafts and Friedel, by means of chloride of aluminum.

Soc. Anon. des Produits Chimiques pour les Sciences, etc., Paris.

Poulenc & Wittmann, Paris. Exhibited a fine collection of general chemicals, cadmium salts, bismuth, permanganate of potassa in very large crystals, and photographic chemicals.

Poulenc & Wittmann.

Tessié du Motay, Paris: Chemicals for bleaching purposes, and binoxide of barium.

Tessié du Motay, Paris.

FRANCE.

Chemical works.

Mulaton & Co., Lyon: Tartaric and citric acids, with their salts.

Mulaton & Co., Lyon.

P. Moreau, Lille: Mineral acids, various sulphates, chloroform, ether, and a fine specimen of tannin.

P. Moreau, Lille.

Faure & Kessler, Clermont-Ferrand.

Faure & Kessler, Clermont-Ferrand: Superphosphates, silico-fluorides of the alkalies, hydrofluoric acid, various derivatives of fluor spar, preparations for etching on glass, chlorate of potassa, apparatus for the concentration of sulphuric acid to 66° B. Since 1873 this firm has delivered sixty-two of their form of evaporators, ranging in capacity from 1,000 to 5,000 kilos of acid per day.

H. Dubois-Caplain, Paris.

H. Dubois-Caplain, Paris: Nitrate of silver, chlorides of gold, platinum, and palladium, metallic platinum and palladium.

De Dienheim-Brochocki, Boulogne.

De Dienheim-Brochocki, Boulogne. Exhibited sulphite of alumina, disinfectants, "chlorozone" for bleaching.

Billault & Billaudot, Paris.

Billault & Billaudot, Paris: This establishment was founded in 1815, and now gives employment to 60 operatives. It exhibited a remarkably fine and complete collection of nearly all chemicals required in the arts and sciences.

Superb exhibit.

It was a superb display and surpassed by far any general exhibition of chemicals in the Exposition. Especially noteworthy were the rich and brilliant crystals of bismuth, erythrit, and a number of double cyanides of platinum with other metals; osmic acid, indigotine, citrate of iron, subnitrate of bismuth, tannin, gallic acid (serving for the manufacture of pyrogallic acid, now extensively used for the fabrication of some new and very beautiful coloring matters), chlorate of barium, phosphide of calcium, etc.

Bordet Frères, Froidvent.

Bordet Frères, Froidvent: Acetic acid and various acetates.

Camus Frères, Nepel & Co., Paris.

Camus Frères, Nepel, & Co., Paris: Fine exhibit of acetic acid and metallic acetates. (This firm has on the Official Catalogue, among the articles exhibited, *méthylène.*)

Collective exhibit; alum and sulphate of iron.

Collective exhibit of the Manufacturers of Alum and Sulphate of Iron: The five firms represented produce annually 6,000,000 kilos of alum of various degrees of purity, and 6,000,000 kilos of ferrous sulphate, from the alumino-ferrous lignite of the region.

A. Hutter & Montpellier.

A. Hutter & Co., Montpellier: Sulphate of alumina prepared from bauxite by Hutter's method (precipitation of the oxide of iron by means of zinc), of which the firm turns out annually 3,000,000 kilos.

Nocq Fils, Pommier, & Co., Noyon.

Nocq Fils, Pommier, & Co., Noyon: Sulphate of alumina, alum.

FRANCE.

Chemical works.

Pommier & Co., Gennevilliers: Alum and sulphate of alumina. Pommier & Co., Gennevilliers.

Mines of Bouxeviller, Laneuveville: This establishment was founded in 1820 and is one of the most extensive in France. It exhibited a magnificent collection of crystals of prussiate of potash. Mines of Bouxeviller.

Le Moulin, St. Denis: Cyanide and prussiate of potassium, salts of tin and caustic alkalies. Le Moulin, St. Denis.

A. de Plazenet, Paris. Exhibited a fine collection of pure chemicals for the laboratory, and of all chemicals used in electro-metallurgy. The annual production of this establishment is as follows: A. de Plazenet, Paris. Annual production.

	Kilos.
Nitric acid	600,000
Cyanide of potassium (of which 10,000 kilos are pure)	60,000
Hydrocyanic acid	3,000
Sulphate of zinc	90,000
Caustic alkalies	15,000
Pyrophosphate of soda	12,000
Sulphate of nickel	15,000
Hydrofluoric acid	8,000

Various cyanides, ferro-cyanides, bisulphite of soda, and salts of gold, silver, and platinum, to the value of $140,000 annually.

Daubin, Paris. Exhibited benzoic acid manufactured from the urine of the cattle in the Paris abattoir. Six thousand head of cattle are received weekly, and the amount of urine collected in the same length of time is 15 cubic meters, which, at the rate of 6 kilos per cubic meter, yields 90 kilos of benzoin weekly, at a cost of 8 frs. per kilo. The annual yield is 4,700 kilos, amounting to 37,600 frs. or $7,520. Daubin, Paris.

Platinum apparatus. Platinum apparatus.

Demontis, Quenessen, & Le Brun, Paris. Exhibited platinum stills, round and ellipsoidal; also a large variety of objects in platinum for technical use, osmium in wire and sheets, palladium, ruthenium, osmium-iridium. Demontis, Quenessen, & Le Brun, Paris.

Godart & Contenau, Paris: Crucibles and other objects in platinum. Godart & Contenau, Paris.

H. Chapuis, Paris. Exhibited Faure & Kessier's apparatus for concentrating 4,000 kilos of sulphuric acid daily, palladium sponge, iridium; stills for preparing hydrofluoric acid. H. Chapuis, Paris.

GREAT BRITAIN.

The chemical industries of England stand undeniably far in advance of those of any other country, not only in respect to extent but also with regard to the rapid march of improvement. This position is due to a variety of causes. Great Britain in advance of other countries in chemical industries.

GREAT BRITAIN.

Britain's eminent advantage in coal, harbors, and sea transportation.

First and principally must be mentioned the immense supply of good coal in advantageous proximity to the harbors or the natural raw materials required in various industries. Then come the numerous extensive havens and the exceptional maritime position of England, allowing cheap transport to all parts of the world of the heavier chemical manufactures. Other valuable adjuncts are to be found in the widespread colonial system, the long-continued freedom from war or revolution, and the rapid contemporaneous development of other manufactures depending on chemical products.

Her colonial system and political stability.

Statistics of British chemical industries.

A few statistics will afford a glimpse of the present condition of Great Britain's chemical industries. Among the imports of raw material for the year 1878, are:

	Kilos.	Value.
Sulphur	44,500,000	$1,235,000
Copper and iron pyrites	609,000,000	7,060,000
Saltpeter	13,400,000	1,427,000
Nitrate of soda	96,400,000	7,250,000

Importations of sulphur and pyrites.

Production of salt.

The amount of sulphur imported diminishes slowly, while the quantity of pyrites imported has been tripled within ten years. It is estimated that over 800,000,000 kilos are manufactured annually. In 1875 the production of salt was 2,316,644,000 kilos. The soda manufacture, based on these two articles, possesses proportions equally vast. In the following table a view is afforded of its condition in 1876 and of its growth during the preceding fourteen years:

Statistics of soda manufacture.

	1862.	1876.
Value of the annual production	$12,500,000	$32,500,000
Weight of the products (dry) ..... kilos..	280,000,000	845,000,000
Raw material used ..... kilos..		
Salt ..... do ..	254,600,000	538,600,000
Coal ..... do...	961,000,000	1,890,000,000
Limestone ..... do...	280,500,000	588,000,000
Lime ..... do...	.....	139,000,000
Pyrites ..... do...	264,000,000	376,000,000
Nitrate of soda ..... do...	8,300,000	12,200,000
Peroxide of manganese ..... do...	33,000,000	18,200,000
	1,801,400,000	3,562,000,000
Capital	$10,000,000	$35,000,000
Annual cost of repairs	$677,500	.....
Annual cost of repairs and packing	.....	$3,500,000
Operatives ..... number..	10,600	22,000
Wages of same	$2,747,000	$7,025,000
Weight of products exported ..... kilos..	104,702,000	270,856,000
Value of same	$4,425,000	$11,045,000

Export of soda, 1878.

The amount of soda exported in 1878, based on the statistics for the first 8 months, was about 275,000,000 kilos,

possessing a value of $9,572,000. The destinations were the following: GREAT BRITAIN.

	Kilos.	
Russia	22,500,000	Soda exported to respective countries.
Germany	40,300,000	
Holland	18,200,000	
Belgium	12,200,000	
France	11,25,0000	
United States	115,400,000	
Other countries	54,150,000	

Great extent of alkali industry of Britain.

The extent of the alkali industry of Great Britain is such at present that it allows the introduction of labor-saving machines on a large scale, far beyond the means of most Continental manufacturers, and it is probable that her supremacy in this branch will be maintained far in the future. As an instance of the gigantic scale on which this manufacture is conducted in England, it may be mentioned that the three establishments of Allhusen, Jarrow, and Tennant produce more than all the twenty works of Germany.

Bleaching powder.

Bleaching powder, which forms such an important adjunct to the alkali manufacture, is produced to the extent of over 100,000,000 kilos annually, and it is almost exclusively to English inventors that the improvements in this branch are due.

Iodine.

The annual production of iodine in Great Britain is over 50,000 kilos.

Chemical works.

The exhibition of the productions of the soda manufacture, as well as of other leading chemical industries, although presenting many points of interest, was far from offering a fair view of their vast extent. Many great establishments were not represented at all at the Exposition.

Forster & Gregory, Streatham Common.

Forster & Gregory, Streatham Common. Exhibited sulphide of carbon, sulpho-carbonate of potash, tetrachloride of carbon, chloride of sulphur, xanthate of potash, chemicals for coloring and vulcanizing india-rubber.

Boyd, Son, & Co., Dublin.

Boyd, Son, & Co., Dublin: Sulphate of soda prepared by Hargreaves's method, richness 99.47 per cent.; chloride of lime, available chlorine=38.7 per cent.

De Soto Alkali Co., Widnes.

De Soto Alkali Company, Widnes: Black ash, soda crystals, fine caustic soda of 60 and 70 per cent.

Golding, Davis, & Co., Widnes.

Golding, Davis, & Co., Widnes: Caustic soda (62 and 67 per cent.), chloride of lime (40 per cent. Cl), sulphate of soda manufactured by Hargreaves & Robinson's process, containing but 0.02 of chloride of sodium. Weekly turn-out of various products, 500,000 kilos.

Runcorn Soap and Alkali Co.

Runcorn Soap and Alkali Company, Widnes: Various products of the soda manufacture, sulphate of soda by Har-

GREAT BRITAIN.

Chemical works.

greaves's process (98 per cent.), caustic soda (60 and 70 per cent.).

Tyne Alkali Co., New Castle.

Tyne Alkali Company, Newcastle: Soda ash (52 per cent.), chlorate of potash, satin white from barium carbonate.

Tennant & Co., St. Rollox.

Tennant & Co., St. Rollox, J. Mactear, director: A remarkably fine exhibit of products representing every stage in the manufacture of soda and the utilization of the waste products. Regeneration of oxide of manganese by Dunlop's method. Mactear furnace for preparing the carbonate, 7 meters in diameter, requiring 30 per cent. of coal, producing 150,000 kilos weekly, and effecting an economy of 60 per cent. on the previous furnaces. By the Mactear method for recovering the sulphur in the waste products, viz, the decomposition of the sulphides of calcium by hydrochloric acid, in the presence of sulphurous acid, which has been in operation for six years, 6,500,000 kilos of sulphur have been extracted and saved.

North British Chemical Co., Glasgow.

North British Chemical Company, Glasgow: Employs 200 operatives. Salts obtained from the charcoal of sea-weed which has been exposed to destructive distillation; ammonia and acetic acid obtained from the products of the distillation. Annual production:

Annual production.

	Kilos.
Iodine	25,000
Bromine	2,500
Iodide of potassium	25,000
Bromide of potassium	25,000
Caustic soda	2,000,000
Chloride of potassium	1,000,000
Chlorate of potash	100,000

Chloricalcium.

As a by-product large quantities of the disinfectant called "chloricalcium" are obtained from the residues of chlorate of potash manufacture. Sea-weed charcoal is another by-product of this industry, which has been largely applied to sewage liquors. Specimens of acetate of lime and sulphate of ammonia as resulting from the subsequent distillation of this substance were on exhibition.

Hargreaves & Robinson, Widnes.

Hargreaves & Robinson, Widnes. Exhibited their apparatus for the manufacture of sulphate of soda by the direct action of sulphurous acid on common salt prepared for the purpose.

W. Weldon, Bairstow.

W. Weldon, Bairstow. Exhibited a complete model of the works necessary for carrying out his process for the regeneration of manganese used in the chlorine manufacture; also a series of specimen products.

Johnson, Matthey, & Co., London.

Johnson, Matthey, & Co., London: This celebrated firm had a very fine and extensive display of platinum apparatus

GREAT BRITAIN.

Chemical works.

for use in large chemical industries; sulphuric acid concentrator; platinum metals, including a large ingot of palladium weighing 68¾ kilos and valued at $50,000, and 2 kilos of ruthenium valued at $8,000; crystallized osmium; palladium disk containing 1,000 times its volume of occluded hydrogen; spongy iridium, etc.

Johnson, Matthey, & Co., London.

Chambers & Co., London: Established in 1837; extensive exhibit of general chemicals.

Chambers & Co., London.

Hurlet and Campsie Alum Company, Glasgow: Exhibited fine specimens of red and yellow prussiate of potash.

Hurlet & Campsie Alum Co., Glasgow.

T. Jennings, Cork. Exhibited his well-known carbonate of magnesia and calcined magnesia.

T. Jennings, Cork.

Langthorne Chemical Works, Stratford. Displayed a large and fine collection of pure chemicals and rare compounds.

Langthorne Chemical Works, Stratford.

J. T. Readman, Glasgow. Sent a fine exhibit of phosphate, sulphite, and stannate of soda, citric acid and phosphorus, with specimens showing the various stages in the different processes.

J. T. Readman, Glasgow.

P. Spence, Manchester: Handsome display of alum crystals, forming a column 12 to 14 feet in height. The weekly production of this salts is 200,000 kilos, and its purity is so great that it is said to contain but 0.0002 per cent. of oxide of iron. Alumino-ferric cake, prepared from bauxite and used for sizing brown paper and for purifying muddy water, sewage, and the waste of factories.

P. Spence, Manchester.

Washington Chemical Works, Newcastle: Pure carbonate of magnesia in enormous blocks.

Washington Chemical Works, Newcastle.

GREECE.

GREECE.

This country is almost devoid of interest in a chemical point of view, having but two exhibits in this branch.

V. Mélas, of Milos. Exhibited sulphur from the mines of Milos, which furnish an ore which yields from 15 to 40 per cent. of sulphur. The ore is treated by the method of Calcaroni or by the system of Doppioni.

V. Mélas, Milos.

A. Cordella, Zéphyria: Specimens of alum obtained from the ancient alum mines of Milos.

A. Cordella, Zéphyria.

All the salt necessary for consumption in the country is extracted from sea-water. Specimens of this necessary chemical were exhibited from Anaryssos (Attica), Domtrène (Thebes), Thermissia (Spetzia), Lamia (Phthiotide), Missolonghi, Naxos, Leucade, Zante, and Corfu.

Sea-salt

HOLLAND.

HOLLAND.

The chemical industries of Holland are mainly subordinate to the stearine works, the sulphuric acid produced barely sufficing for the saponification of the fats consumed in the works.

Hartogh & Co., Amsterdam.

Hartogh & Co., Amsterdam: Established 1872. Bisulphide of carbon prepared by a new process at a cost of but 7 cents per kilo. It is chiefly used in the establishment for the extraction of oils from the residues.

Ketjen & Co., Amsterdam.

Ketjen & Co., Amsterdam: Established 1835; employ 29 workmen and 15 horse-power; produce sulphuric acid, nitric acid, hydrochloric acid, sulphates of soda and iron, the annual production of sulphuric acid being 2,500,000 kilos. The vitriol chambers have a capacity of 6,000 cubic meters.

Krol & Co., Zwolle.

Krol & Co., Zwolle: Produce superphosphates and sulphate of ammonia, specimens of which were on exhibition.

ITALY.

ITALY.

Scarcity of fuel prevents development of chemical industries.

The absence of coal deposits and the general scarcity of combustible matter of every description have hindered the chemical industries of Italy from making the rapid development which would otherwise have been expected from the mineral treasures of the kingdom. Although the number of exhibitors was large, the number of firms of importance represented was exceedingly limited. The extraction of

Sulphur the most important branch of industry.

sulphur forms a most important branch of industry in the kingdom. The total amount extracted yearly is about 280,000,000 kilos. It gives employment to 22,817 workmen. Sulphuric acid is manufactured in 7 establishments, 4 of which, however, consume in other operations the acid they produce With the exception of the firm of Sclopis &

Sulphuric-acid works.

Bechis, at Turin—who use pyrites—all of the works prepare the acid directly from sulphur. Large quantities of sulphuric acid are imported, mostly from France. A single establishment for the manufacture of soda has been in operation at Leghorn since 1872. Next to sulphur, boracic acid

Boracic acid.

is the most important natural product. In Tuscany, besides the seven establishments belonging to the famous Larderel family, there are three others of less importance. The total

Annual product.

annual production amounts to 2,500,000 kilos.

On the island of Vulcano an English company extracts annually 3,000 kilos of this acid from the emanations of the still active volcano. Cream of tartar and tartaric acid engage the attention of a number of smaller manufacturers. Alum is manufactured on a large scale in three establish-

ments in Central Italy. Notwithstanding her natural richness in dolomite, Italy prepares but one-half of the magnesia compounds required in the kingdom. Bisulphide of carbon, used to a considerable extent for the extraction of oils from the residues of the oil presses and from other matters, is manufactured by two firms to the extent of 500,000 kilos annually.

ITALY.

Chemical industries.

Bisulphide of carbon.

Sulphur, in the natural state as well as refined, was displayed by fifteen exhibitors, the most of whom were from Sicily. Their names and addresses are as follows:

Exhibitors of sulphur.

Albani Mines, at Pesaro: Annual product in all forms 1,000,000 kilos.

Chamber of Commerce of Caltanissetta.

Chamber of Commerce of Catania.

Chamber of Commerce of Girgenti.

A. Cangiotti, Pesaro: Annual production about 1,500,000 kilos.

Cesena Sulphur Company, limited.

N. Dellamore & Co., Cesena.

D. Di Marzo, Tufo.

G. Di Marzo, Tufo.

F. P. Pantano & Son, Assoro.

E. Ruffi, Rimini: Annual production 1,000,000 kilos.

Romagna Sulphur Company, Bologna.

General Sulphur Company, Brescia: Production 700,000 kilos.

Nicotera & Co.

F. Zampari, Altarilla.

Pereira, Mario, & Co., Pisa. Employ 30 workmen and produce 2,000,000 kilos of bisulphide of carbon annually, the whole of which is used for the extraction of oils and of sulphur.

Pereira, Mario, & Co., Pisa.

Società Anonima per la Fabbricazione delle Soda, Leghorn: Established 1872; exhibit various products of the soda industry, sulphates and borates. This establishment is the first erected in Italy for the manufacture of soda, and is still comparatively in its infancy.

Soc. Anon. per la Fabric. delle Soda, Leghorn.

B. Baroncelli, Florence: Bicarbonates of soda and potash.

B. Baroncelli, Florence.

Candiani & Biffi, Milan. Have 60 operatives; capacity of vitriol chambers 1,500 cubic meters. The establishment consumes annually 540,000 kilos of sulphur, and manufactures 3,300,000 kilos of sulphuric acid at 50° B. Other products are nitric acid, 407,000 kilos; hydrochloric acid 203,500 kilos; sulphate of zinc, 25,000 kilos; preparations of iron for paints, 150,000 kilos; sulphate of soda, 550,000 kilos;

Candiani & Biffi, Milan.

ITALY.

sulphate of alumina, 300,000 kilos; soluble silicates, 20,000 kilos; superphosphates, 50,000 kilos.

Sclopis, Bechis & Co., Turin.

Sclopis, Bechis, & Co., Turin: Established in 1812; capacity of vitriol chambers 8,000 cubic meters. Since 1856 this house has found it advantageous to replace Sicilian sulphur by the rich pyrites of the Aosta Valley. It likewise makes extensive use of giobertite, a very pure hydrocarbonate of magnesia found in the neighborhood, for the manufacture of sulphate of magnesia.

Consumption of raw material.

Annual consumption:

	Kilos.
Pyrites	3,000,000
Coal	2,000,000
Iron refuse	120,000
Giobertite	400,000
Gas water	860,000

Annual production.

Annual production:

Sulphuric acid, 50° B	3,000,000
Sulphate of iron	350,000
Sulphate of magnesia	500,000
Sulphate of soda	50,000
Sulphate of ammonia	60,000
Acetate of iron	20,000
Oxide of iron	20,000

Soc. Gén. des Alums, Civita Vecchia.

Société Générale des Alums, Civita Vecchia: Alum and sulphate of alumina.

A. Conti, Castro-caro: Iodine, iodides, and bromides from the mother-liquors of mineral waters.

P. Camboni, Brescia.

P. Camboni, Brescia: Handsome exhibit of carbonate of magnesia, of which 40,000 kilos are produced annually by 25 operatives. The dolomite from the vicinity of Lago di Guarda is burned in kilns and treated with water. The hydrates of lime and magnesia are then treated with an excess of carbonic acid obtained from the kilns, and the solution of bicarbonate of magnesia separated from the carbonate of lime. On boiling the solution a very fine carbonate of magnesia is precipitated as a light powder.

F. de Larderel, Leghorn.

F. de Larderel, Leghorn: Boracic acid extracted from the fumeroles of Tuscany. The extraction of this acid, begun by Francis Larderel in 1848, is now conducted in seven different establishments and occupies over 1,000 operatives. The annual yield is about 2,000,000 kilos.

NORWAY.

NORWAY.

Chemical works in Norway are still few in number, limited in extent, and do not supply the chemicals required in the land. The absence of cheap fuel is an insurmountable obstacle to progress in this branch of industry.

Chemical Works of Stavanger: The various products of the soda industry, sulphuric and hydrochloric acids. Chemical works of Staranger.

Lysaker Chemical Works, Christiania: Nitric and sulphuric acids. Lysaker Chemical Works.

Leeren, Trondhjem: Bichromate of potassa. Leeren, Trondhjem.

Jacobsen & Co., Fredriksstad: Oxalic acid manufactured from saw-dust; a handsome exhibit. Jacobson & Co., Fredriksstad.

RUSSIA.

Notwithstanding the enormous market open in the empire itself and in the adjoining Orient, Russia makes but slow progress in the chemical arts. Among the more apparent hinderances to a more rapid development are the absence of sufficient means of transport, the distance of the coal mines from the industrial centers, and the necessity of resorting to other countries for machines, as well as for persons of chemical and technical experience. The exhibits offered but little of interest. Slow progress. Owing to insufficiency of transport, distance of coal, lack of machinery and technical experience. *Chemical wrrks.*

Russo-American Caoutchouc Manufacturing Company, St. Petersburg: This is one of the most extensive manufacturing establishments in Russia in which a chemical art is carried on. It was organized in 1860, and has so grown in extent and importance in seven years that its products in 1867 amounted to 4,000,000 of rubles. It employs ten steam-engines, with an aggregate power of 760 horses, and works 750 male and 800 female hands. Russo-American Caoutchouc Co.

Compagnie de la Fabrique de Tentelevo, St. Petersburg: 60 operatives, 34 horse-power, value of annual production $126,000. Acids, refined saltpeter, sulphates, ammonia salts, etc. Comp. de la Fabrique de Tentelevo, St. Petersburg.

N. Lepehkine, Moscow: Established in 1826, employs 360 hands, and uses 3 platinum stills. Value of annual production $700,000. This establishment, which before the discovery of artificial alizarine was devoted chiefly to the manufacture of garancine, is now occupied, for the most part, with the preparation of the mineral acids, various sulphates and alums, and a number of other salts. N. Lepehkine, Moscow.

G. S. Rasterayeff, St. Petersburg: Established in 1848, with 120 workmen; the various acids and alkalies, sulphates, citrates, soda salts, refined sulphur. Annual production 1,300,000 kilos, valued at $250,000. G. S. Rasterayeff, St. Petersburg.

P. Ouchkoff, Yelaboug: Established 1850: employs 600 men and runs 12 furnaces: produces alum, sulphuric acid from pyrites, sulphate of copper from copper pyrites, chromate of potash. Value of annual production $577,000. This establishment was the first in Russia to make use of the P. Ouchkoff, Yelaboug.

RUSSIA.

rich Siberian deposits of chromate of iron, which had hitherto been sent almost entirely to England. The products a e largely exported to Asia.

M. Prang, Barnaoul.

M. Prang, Barnaoul, Siberia: This establishment was started in 1864, and produces soda salts, being the first to use the natural sulphate of soda obtained from Siberian inland seas. Articles exhibited, soda and caustic soda. Annual production 550,000 kilos, value $42,000.

E. Wargounine, St. Petersburg.

E. Wargounine, St. Petersburg: Employs 80 workmen; produces acids, sulphates, tin and lead salts, and general chemicals. Value of annual production $126,000.

Werner & Hallé, Warsaw.

Werner & Hallé, Warsaw: 45 operatives, 18 horse-power. Produce annually $63,000 worth of carbonate and sulphate of magnesia, saltpeter, chromic acid, etc.

SPAIN.

SPAIN.

Spain possesses an immense wealth in natural products; still the great chemical industries have as yet established no foothold there. Coal, sulphur, pyrites, salt, oxide of manganese, in fact all natural raw material necessary for the manufacture of soda, are found in abundance, but until now they form only leading sources of supply for France, and especially England. The annual yield of pyrites is over 440,000,000 kilos; sulphur, 1,650,000 kilos; oxide of manganese, 35,000,000 kilos; and salt, 400,000,000 kilos. The exhibitors were:

Abundance of raw material, but few chemical industries.

Exhibitors.

Campo & Co., Haro: Cream of tartar.

Chaves & Gonzalez, Bollulos: Cream of tartar.

S. Nadal, Lerida: Soda ash.

Count de Torregrosa: Soda ash.

Lagrera & Escales, Felanix: Ether.

Resola Bros.: Sulphuric and nitric acids and soda.

Alkalies and acids were also exhibited by several English firms.

SWEDEN.

SWEDEN.

The chemical industries, although growing rapidly, are as yet unable to meet the demands of the kingdom. Sulphuric acid is produced to the extent of 4,870,000 kilos annually, and is consumed almost entirely in the manufacture of superphosphates, of which 8,500,000 kilos are annually produced in four factories. The wasteful preparation of potash by combustion in the more densely wooded regions is rapidly diminishing. The preparation of saltpeter from urine and ashes is also becoming less customary, and now produces but 21,200 kilos annually. The exhibitors were:

Growing, but still insufficient chemical industries.

Superphosphates.

Mines of Storra.

Mines of Stora-Kopparberg: By-products of the rich py-

rites deposits of the neighborhood, sulphuric acid, oxide of iron, sulphates of iron and copper, and sulphur. This establishment is well known as the scene of Berzelins's discovery of selenium. SWEDEN.

SWITZERLAND.

SWITZERLAND.

The almost entire absence of coal and of deposits of raw material requisite for chemical manufactures has been a serious drawback to the development of these industries in Switzerland, and it has been overcome on a large scale by but a single firm. Deficiency of coal and raw material for chemical manufactures.

C. Jetzler, Schaffhausen. Exhibited a plan of installation for a new method of regenerating oxide of manganese. C. Jetzler, Schaffhausen.

Schnorf Bros., Uetikon: Established in 1818; employ 100 workmen and 14 horse-power. This establishment, founded for the manufacture of sulphate of copper, began the manufacture of sulphuric acid in 1824, and in 1870 substituted for Sicilian sulphur the well-known Lyon pyrites. It was the first to overcome the natural difficulties facing the chemical industries in Switzerland, resulting from a lack of fuel and raw material, and it produces at present about 6,000,000 kilos of chemicals, representing a value of $600,000. Seventy-five hundred kilos of pyrites are used daily, the sulphuric acid being formed in four series of vitriol chambers, and two-thirds of it being used for the preparation of sulphate of soda. The soda production consists of 350,000 kilos of a very pure sulphate of soda and 1,500,000 kilos of soda crystals, 750,000 kilos of hydrochloric acid, 250,000 kilos of chloride of lime, 250,000 kilos of nitric acid, 50,000 kilos of tin salts, 1,500,000 kilos of sulphate of iron, 750,000 kilos of iron liquor (prepared by oxidizing sulphate of iron with nitric acid, and greatly in request among Swiss silk manufacturers), chloride of zinc for the impregnation of railway ties, and pure acids and salts. Schnorf Bros., Uetikon. Sulphuric acid works. Soda, etc.

SOUTH AND CENTRAL AMERICA.

SOUTH AND CENTRAL AMERICA.

Peru exhibited specimens of iodine, saltpeter, and nitrate of soda.

Guatamala exhibited white lead and refined saltpeter and alum.

The Argentine Republic exhibited soda ash, cream of tartar, and sulphur.

UNITED STATES OF AMERICA.

UNITED STATES OF AMERICA.

In general the chemical industries of the United States are far removed from the stage of development warranted

UNITED STATES.

Our deficiency in chemical manufactures. Our dependence on Europe.

by the natural wealth of the country and the high degree of perfection attained in other branches of manufacture. The state of dependence on Europe for so many articles is, however, constantly growing less, and it is to be hoped from the progress made during the past few years that before no distant date as important a change will be effected in this respect as has been lately the case with regard to numerous branches of textile and metallurgical industry. As noteworthy indications of the movement in this direction, may be mentioned the rapid development of the bromine manufacture in the Ohio Valley, which in the course of a few years has assumed such dimensions as to practically command the market of the world; and the equally rapid extension of the borax production in the Pacific States, which causes no small degree of anxiety among European manufacturers of this article.

Bromine industry of the Ohio Valley.

Borax production of the Pacific States.

Philadelphia the chief center of chemical industry. Followed by New York and Boston.

Philadelphia is the chief center of chemical manufacture, New York and Boston following second and third in the list. According to statistics collected in 1875, there were in Philadelphia and its environs 245 chemical works, with an annual production valued at $31,298,000, and divided as follows:

Production of Philadelphia chemical works.

Chemicals	$12,000,000
Pharmaceutical products	3,500,000
Soap	3,048,000
Oils and petroleum	3,500,000
Colors	3,964,000
Perfumes	1,125,000
Gas and by-products	4,161,000

Imports of Sicilian sulphur.

The imports of sulphur from Sicily have mounted from 19,830,000 kilos in 1872 to 32,656,000 kilos in 1877. It is probable that an energetic development of the extensive deposits in the Pacific States will soon enable the country to be entirely independent of the European source. The manufacture of sulphuric acid assumes daily more important proportions since its extended application in the petroleum refineries. Sulphur is at present almost the sole material used for this manufacture. The deposits of pyrites, although widespread and of fair average quality, are still generally too remote from industrial centers to be utilized for this purpose, and the prospects of a rapid extension of the sulphur supply in the West has prevented any notable disposition for their use in the various works. The alkali industry remains still in its infancy. Apart from the production of the well-known works in Pennsylvania, which make use of the greater part of the cryolite obtained in Greenland, the wants of the country in this direction are

Pacific coast deposits.

Alkali industry in its infancy.

UNITED STATES.

met by importation from England. The amount of this importation in 1878 was over 115,000,000 kilos. The discovery of extensive deposits of natural soda in the western section of this country, at points not far distant from the Pacific Railroad, will be likely to bring about an important change in the source of this article. On account of the climate, the manufacture of bleaching powder is attended with such difficulties that almost the entire quantity of this product required in the United States is likewise imported from England. The import amounted to 22,000,000 kilos in 1876. Saltpeter is an article of comparatively recent manufacture. During the past two years, however, this industry assumed such proportions that large quantities were exported to Rus sia during the late war.

Imports of soda.

Western soda deposits.

Imports of bleaching powder.

Saltpeter.

Among other branches which are of constantly growing importance are the manufactures of red and yellow prussiates of potash, of alum, and of borax. The deposits of borax in the United States are at present being developed with great rapidity, and the supply of 200,000 kilos monthly is not only sufficient for the needs of the country, but affords a considerable surplus for exportation. The production of bromine, which has increased in ten years from 5,000 kilos to 125,000 kilos, has rendered possible the use of this valuable element in numerous operations where chlorine has hitherto been applied.

Manufactures of prussiate of iron, alum, and borax.

Bromine.

Unfortunately, the exhibits of the products of the great chemical industries were of the most limited character, and afforded no just view of the progress made of late years in this department of industry in our country.

Very limited exhibit.

The following were the only exhibitors of chemical products in the United States section:

Exhibitors.

H. J. Baker & Bro., New York City. Exhibited very handsome specimens of borax, refined saltpeter, camphor, and epsom salts. The products of this firm compare favorably with those of any other establishment represented.

H. J. Baker & Bro.

Henry Bower, Philadelphia: This exhibitor displayed in a very modest and unostentatious style his superior glycerine in one-pound bottles; specimens of handsome yellow prussiate of potash, and some ordinary sulphate of ammonia.

Henry Bower.

Hance Bros. & White, Philadelphia: A number of very beautiful specimens of chemical preparations for medicinal use were included in the pharmaceutical display made by this firm. The following were especially noted for their finished and handsome appearance: Monobromated camphor,

Hance Bros. & White.

UNITED STATES. hydrochlorate of berberine—both preparations in crystals prepared with much skill and care.

A. Pirz. A. Pirz, Carniola Chemical Works, Long Island City. Exhibited a specimen of pure acetate of lead.

C. T. White & Co. C. T. White & Co., New York: The collection of specimens representing this house consisted of morphia and its salts, crystallized strychnia, valerianate of quinia, and iodides and bromides of potassium, etc., all of which were of the best quality and presented quite a handsome and creditable appearance. These products were as good and as prepossessing as any shown in the Exposition, and very much handsomer than most that were exhibited.

Many of the exhibitors in Class 47 sent specimens of chemical, pharmaceutical, and tinctorial products, and in consequence of this diversity in the exhibits the same firms may appear under several heads.

Alizarine.

ALIZARINE.

Its discovery an epoch in chemical science. Graebe & Liebermann's discovery forms an epoch in the history of organic chemistry, alizarine being the first natural dye-stuff which has been prepared artificially. Since that time the manufacture of this body from anthracene has assumed very large proportions. According to the official report on the Vienna Exhibition of 1873, there existed at that time ten or twelve alizarine works in Germany, while England and France possessed one each. The total quantity of alizarine manufactured in the year above mentioned was about 2,500,000 kilos of alizarine paste, containing 10 per cent. of coloring matter, representing at that time a value of $3,000,000, gold. Since that time the annual product has greatly increased, and it may safely be put down at double that amount. The total amount of madder which hitherto has been used per annum may be estimated at one million hundredweight, with a value of $10,000,000. It can fairly be assumed that there exists in coal-tar a quantity of anthracene which is more than sufficient to manufacture an amount of alizarine equal to that contained in the above-mentioned quantity of madder.

The first artificial production of a natural dye-stuff.

Production in 1873.

Now probably double.

Former amount of madder used, 100,000,000 lbs.

The discovery of the artificial production of alizarine rests on an observation made by Graebe & Liebermann, in 1868, that alizarine bore a very close relation to anthracene, $C_{14}H_{10}$. They succeeded not only in reducing alizarine to anthracene, but also in converting the latter into the former by a process of synthesis. They took advantage of a discovery pre-

Graebe & Liebermann.

viously made by Anderson that when anthracene is heated with nitric acid it is oxidized to a yellow crystalline body, which he called oxyanthracene, $C_{14}H_8O_2$, now known by the name anthraquinone. On heating this body with bromine it yields dibromanthraquinone, $C_{14}H_6Br_2O_2$, and on melting this with caustic potash it is converted into alzarine according to the following equation—

Alizarine.

Conversion of anthracene into alizarine.

$$C_{14}H_6Br_2O_2+2KOH=C_{14}H_8O_4+2KBr.$$

Many other and cheaper processes for preparing this substance have since been discovered and patented, and the dye-stuff is sold in the markets of the world at a price which bids fair to drive madders out of use entirely, and thus liberate the thousands of acres of the most fertile lands to the culture of cereals or other products of more immediate necessity to the rapidly increasing population of a crowded world. This coloring matter may also be obtained by another and a much cheaper process, which avoids the tedious operations incident to the formation of anthraquinone and its bromated compound, and a beautiful product is offered to dyers at a greatly reduced price. The process may be summarized thus: Anthracene is converted into a sulpho compound by means of a sulphuric acid aided by heat, from which reaction results anthracene-sulpho acid, $C_{28}H_{18}SH_4O_3$. After proper dilution with water, the solution is oxidized with chromic acid, binoxide of manganese, or other similar bodies, and afterwards neutralized with chalk or pounded limestone. The oxidized acid is then converted into a potassium salt, and heated with caustic potash, by means of which alizarate of potassium is formed, and finally the alizarine is set free by hydrochloric or sulphuric acid.

Probable entire disuse of madder.

Process of conversion of anthracene.

One of the largest manufacturers of this coloring matter, Messrs. Bindschedler & Busch, of Basle, Switzerland, who displayed a magnificent collection of the latest novelties in artificial colors in the Palais du Champ de Mars, have allowed the following process to be published: Before commencing the oxidation they sublime the anthracene in a special apparatus by means of superheated steam, and finely pulverize the product. They state that by their process of sublimation not more than 2 to 3 per cent. of the material is lost, and a comparatively pure product is obtained. Preliminary to the main operation they ascertain, by testing, the exact theoretical amount of bichromate of potassa necessary to oxidize the anthracene only, so as not to employ an excess which would attack other hydrocarbons that may be present, since the latter when oxidized are dissolved in the subsequent steps

Process of Bindschedler & Busch.

Sublimation.

Alizarine.

of the process of the purification of the anthraquinone, and being carbonized by the sulphuric acid, would soil the product.

In large wooden tanks lined with lead and provided with mechanical agitators, 200 kilos of sublimed and finely powdered anthracene are mixed with 3,000 liters of water, heated to the boiling point by steam, containing in solution 192 kilos of bichromate of potassa. After the mixtion is complete a small stream of 272 kilos of sulphuric acid of 66° diluted with water to the strength of 30° Baumé, is allowed to run slowly in for 8 to 10 hours, during the whole of which time the stirring must be uninterrupted. The steam must be nearly or quite cut off, as the entrance of the acid disengages sufficient heat to maintain the ebullition. Towards the end of the reaction the steam should be let on again.

Process of Bindschedler & Busch.

Crude anthraquinone.

The thick mass of crude anthraquinone is then washed and dried, and forms a yellowish-red powder, weighing about 230 kilos. The mother-waters contain the sulphates of chrome and of potassa, which are evaporated and treated to recover the chrome.

For the purification of the crude anthraquinone, 220 kilos of it are very slowly added to 600 kilos of sulphuric acid of 66° Baumé, heated to 80° C. in a large cast-iron boiler furnished with a mechanical agitator; the temperature rises to 100° C., and it should not be allowed to exceed that degree, but should be maintained at that point until the whole of the anthraquinone is dissolved, and a test portion of the mixture when thrown into water lets fall a white precipitate. The mass is then run into large shallow leaden pans and allowed to get completely cold, and the black crystalline mass is then boiled up in 20 times its weight of water. The solution is passed through a filter press and the anthraquinone is washed free from the sulpho acids resulting from the action of the sulphuric acid on the impurities in the anthracene. When the oxidation has been pushed too far not only are the wash-waters of a dark and troubled appearance, but the quinone is likewise dark colored. If the operation has been successfully carried out a yield of 122 kilos of purified anthraquinone should be obtained. It should present a grayish color and a crystalline structure and contain 90 per cent. of the pure substance, which may be further purified by boiling it with a dilute solution of carbonate of soda. This, when washed and dried, contains from 93 to 96 per cent.; but if resublimed with care a sublimate containing 98 per cent. may be obtained. Two hundred kilos of anthracene should yield 118

Purified anthraquinone.

kilos of purified anthraquinone, which sells now for $1.30 per pound. *Alizarine.*

Alizarine (bluish hue) is prepared from the above by mixing 100 kilos each of anthraquinone and sulphuric acid (composed of 55 per cent. of monohydrate and 45 per cent. anhydride), the latter previously liquefied on a sand bath in an enameled boiler provided with a mechanical stirrer and heated by means of an oil bath. The heat is very gradually raised until a temperature of 160° C. is attained, and the mass is kept at that degree for an hour. The contents of the boiler are then drawn off or emptied into a sufficient quantity of boiling water, which is maintained at that temperature for some time; the whole is then thrown into a filter press, in which the undissolved quinone (about 25 per cent.) is retained, washed, and dried. The filtrate and wash-waters contain principally anthraquino-monosulphurous with a little disulphurous acid, which are to be separated. The mixed acids are saturated with soda-lye, when, on cooling, the anthraquino-monosulphite of soda precipitates out in pearly white scales, which may be rendered chemically pure by recrystallization. The mother-waters contain the anthraquino-disulphite of soda, together with a little of the mono-salt.

Process of Bindschedler & Busch.

Preparation of bluish hue alizarine from anthraquinone.

On concentrating the mother-waters the mono salt crystallizes out by refrigeration and leaves the di-salt nearly pure, along with a little sulphate of soda, which is got rid of by evaporating the solution to a density of 30° Baumé, and cooling, when the sulphate of soda crystallizes out. The filtrate is evaporated to dryness, fused, and furnishes a very yellow alizarine.

Yellow alizarine.

One hundred kilos of anthraquinone treated by fuming sulphuric acid are distributed as follows: 25 kilos are unattacked, 50 kilos go to form anthraquino-monosulphurous acid, and 25 kilos go to produce anthraquino-disulphurous acid. Anthraquino-monosulphite of soda, several times recrystallized, on fusion produces the varieties of alizarine specially employed for coloring violet shades of red, and it represents a nearly pure alizarine.

Alizarine of violet shades of red.

For the fabrication of alizarine with a yellowish reflection, 100 kilos of anthraquinone is heated to 160°–170° C. with 200 kilos of fuming sulphuric acid (containing 45 per cent. of anhydride), with constant agitation in the manner above described, until a few drops of the mixture taken out as a test dissolve completely in water. The mass is maintained at the temperature designated for an hour, when it

Alizarine with yellowish reflection.

Alizarine. is turned into water, dissolved, neutralized with caustic soda, evaporated, and fused.

Process in closed vessels under pressure. The fusion of the mass was formerly done in open vessels, but it was attended with great loss of alizarine on account of the regeneration of anthraquinone, and the dye-stuff obtained was impure. It has been found that when the fusion is accomplished in closed vessels and under pressure, and especially in presence of an oxidizing body, as chlorate of potassa, the yield is much greater and the product purer. It is sent into commerce in the shape of paste, containing from 10 to 20 per cent. of dry alizarine.

Rapid growth of the anthracine industry. The growth of the anthracine industry has been no less rapid than its discovery and chemical history has been wonderful. In less than a year after its discovery there were five works in Germany and one in England engaged in its manufacture on a large scale. In 1876 Germany sent into commerce 4,000,000 kilos of alizarine paste of 10 per cent. strength. In 1871 it fetched 26 fr. the kilo, in 1877 it was sold for 5 fr., and during the first half of 1878 the price fell to 3.10 fr., and for a little while at 2.80 fr. the kilo (28 cents per pound). During last August and September the price went up on account of a rise of 45 per cent. in the market price of bichromate of potassa.

Reduction in price.

Cause of the low prices. To overproduction of anthracene and its derivatives, together with the universal depression in all industries, is attributed the exceedingly low price of this valuable dye-stuff.

Derivatives of alizarine. Among the colored derivatives of alizarine, nitro-alizarine should be noticed as one which possesses considerable industrial importance, owing to the lively and "fast" orange color which it communicates to cloth. It was first produced economically on the large scale at the Baden Aniline and Soda Works, and now its manufacture is carried on in almost all the establishments engaged in the anthracene colors industries.

Nitro-alizarine.

Preparation of nitro-alizarine. This chemical is prepared from a pure alizarine made from anthraquino-monosulphurous acid perfectly free from the di-acid. It must be dry and in a finely powdered condition and mixed with a sufficiency of petroleum ether ("benzine"). Into this mixture nitrous acid is passed until a test portion, dissolved in a little boiling water, gives on the addition of an alkali a distinct orange coloration; the current of nitrous acid is then stopped and the mixture thrown on a filter, and the residue pressed. This is then dissolved in a boiling diluted solution of soda, the ebullition being kept up until the whole of the "benzine" is got

Alizarine.

rid of, after which the nitro-alizarine is precipitated from its combination with the alkali by means of hydrochloric acid and drained on a filter until it is reduced to a paste containing 10, 15, or 20 per cent. of "alizarine orange."

Preparation of nitro-alizarine.

Alizarine orange.

A cheaper and simpler process than the one above referred to is employed in some works for the preparation of this color, consisting principally in substituting the "chamber crystals" from vitriol works, instead of nitrous acid especially prepared.

Anthracene blue.

This body not only serves an important purpose as a dye stuff, but it has lately assumed the role of a *matière première* in the manufacture of anthracene blue, which is attracting so much attention as a succedaneum for indigo. Dr. Koch, chemist to the manufactory of Bindschedler & Busch, of Basle, gives the following summary of the process employed in their works: Equal parts of very concentrated sulphuric acid and anhydrous glycerine are mixed and heated to 200° C., with a fiftieth of their weight of dry nitro-alizarine powder; after the reaction is accomplished the product is turned into a dilute solution of alkali, zinc dust added, and heat applied. After the reduction by means of the zinc dust is finished, the whole is thrown on a filter; the alizarine blue formed and remaining in the filtrate is precipitated out by means of a current of air. This coloring matter is very slightly soluble and forms nearly insoluble lakes with lime; consequently its application in dyeing is attended with more difficulty than is experienced with alizarine.

Process.

Tints obtained from anthracene blue.

This new color gives greenish-blue lakes with lime, baryta, and iron; a reddish-blue with alumina; a violet-blue with chrome, and a red-violet with tin. Stuffs mordanted with these salts will consequently be dyed in corresponding colors; that obtained on cloth mordanted with iron salt resembles closely the color produced under like circumstances by indigo. These colors are all distinguished for their great permanence and ability to resist the action of detergents, being altered neither by soap nor chlorinated lime. Like indigo, alizarine blue may be reduced in presence of an alkali, with zinc powder, hydrosulphurous acid, or glucose, and gives a yellowish-brown solution, from which mordanted goods extract the reduced color, and on exposure to the air they become blue by its oxidation.

Behaves like indigo when reduced and subsequently oxidized.

Alizarine blue.

ALIZARINE BLUE.

Report of Koechlin & Prud'homme.

[Extracted from report of MM. Koechlin & Prud'homme, of Mulhouse.]

This body, notwithstanding its derivation and name, should be classed with indigo, as it possesses properties *sui generis*, and would occupy a place intermediate between indigo and alizarine. Alizarine blue is found in commerce in the form of purplish-brown or bluish paste, containing 10 per cent. of coloring matter. When crystallized out of its benzine solution it takes the shape of purplish-brown needles, with a metallic luster. It fuses at 170° C., giving off orange-red vapors, which condense on cool surfaces, taking the shape of needles of a bluish-black color. It is nearly insoluble in water, but it is soluble in small proportion by alcohol and benzine, giving rise to red solutions.

Its character.

Behavior under treatment with acids, etc.

Concentrated sulphuric acid dissolves it to a very fine red solution, which, when heated for some time and treated with water, lets fall a blue precipitate, which seems to possess all its primitive tinctorial powers. Arsenic acid of 70° B. dissolves it easily to an orange-red solution, which passes to the color of fuchsine red on the addition of glycerine. With lime, baryta, and strontia it gives blue-green or green-blue lakes. A boiling solution of alum or of sulphate of alumina does not dissolve a trace of this coloring matter, a property sufficient to characterize it, and serves as a distinct line of demarkation between it and alizarine and purpurine.

Hues obtained by mordanting.

In dyeing, the hues obtained by the use of different mordants are as follows:

With alumina.....Purplish blue.
With iron.....Greenish blue.
With chrome.....Violet.
With tin.....Reddish violet.

Oxide of nickel fixed upon the tissue is dyed, according to M. Dollfus, of a much purer blue than with other mordants.

Preparing the dye bath.

Being almost insoluble in water, it is necessary to add a little soap, or preferably sulpholeic or sulpho-ricinic acid, with a slight excess of ammonia, to the bath. The proportions may be as follows:

1 part of alizarine blue of 10 per cent.
1 to 2 parts of fat acid.

The bath should be heated to 70° C. and gradually (in one hour) brought up to the boiling temperature, at which it should be maintained for half an hour. The presence of

Alizarine blue.

certain salts, phosphate of soda for example, seems to favor the operation of dyeing with this matter. The whites are slightly affected during the operation, and should be at once subjected to soaping at 50–60° C.

Koechlin & Prud'homme.

Properties of the dye.

This dye enjoys the singular property which indigo possesses of becoming reduced in alkaline solution, and may consequently be used in the same manner for dyeing. For cotton goods the bath is reduced with zinc and soda or by hyposulphite of soda. The tissue after passing through the bath is exposed to the oxidizing influence of the air, and the operation is repeated until the depth of tone desired is attained, after which the tissue is passed through a weak solution of chloride of lime or of bichromate of potash, to which a little lime-water is added.

The bath and its management.

Alizarine blue for printing goods.

Solution of reduced alizarine blue may also be applied by printing, and the following mixture gives good results so far as brightness and vivacity of tint are concerned, but it does not resist the action of soap or of light:

Alizarine blue, 10 per cent	$\frac{1}{4}$ liter.
Solut. dextrine (1,000 grams to liter)	$\frac{1}{2}$ liter.
Glycerine of 28°	$\frac{1}{16}$ liter.
Sal caustic soda of 36°	$\frac{1}{16}$ liter.
Zinc dust	25 grams.

Fixing the color.

The want of permanence of this color is owing to the absence of mordant, and if chrome or iron in the form of salts not precipitable by alkalies are added the color is rendered comparatively "fast."

The violet tint.

Alizarine blue reduced by stannite of soda and thickened with dextrine gives, on steaming, a violet which resists well the action of soap.

"Blue faïence."

This body may also be fixed upon the tissue by a process analogous to that called *bleu faïence*, made by printing rather heavily and passing the goods alternately through a reducing and an alkaline bath.

Valuable quality of alizarine blue.

The real value of alizarine blue consists in the facility of its application to the tissue by the process of steaming and its *solidité*. These qualities, if it were not for its very high price at present ($1 per pound of the 10 per cent. paste), places it at once in a superior position to ultramarine and indigo.

Mordants.

The best mordants are ferrocyanide of potassium or ammonium and acetate of chromium, which give fast colors but a blue slightly purplish. The addition of acetate of lime to the paste to turn the tint towards greenish blue is not attended with advantage. The color is purer, but it has no brilliance or "vivacité." M. Dupuy employs acetate of

Alizarine blue. chromium and chloride of calcium concurrently. It has been found, however, that chloride of magnesium serves a better purpose than the latter, and the following color is recommended:

Koechlin & Prud'homme.

Compounding the color.

Thickening	250 grams.
Alizarine blue of 10 per cent	50 grams.
Acetate of chromium of 10 per cent	16 cubic centimeters.
Chloride of magnesium of 10 per cent	16 cubic centimeters.
Ferrocyanide of potassium of 10 per cent	8 cubic centimeters.
Glycerine	32 cubic centimeters.

Thickening. The thickening is composed as follows:

Water	3 liters.
White starch	125 grams.
Lightly roasted starch	375 grams.
Olive oil	150 grams.

Mix and boil for one hour over a very gentle fire.

Printing. The color is printed on the tissue prepared with a moderately strong sulpholeic acid solution (1 part to 20 to 30 of water), a condition essential to success.

Steaming. The steaming should have one and a half to two hours, and the washing and soaping at 50° C. should last 20 minutes. The goods should then be passed through a boiling bath of lime containing 1 gram of quicklime to the liter of water, which serves to communicate a greenish tint on account of the formation of a calcareous lake. Afterwards it is to be well

Washing. soaped and washed in boiling water, this treatment bringing out the color to a pure blue. Baryta and strontia produce the same effect on anthracene blue as lime does.

The color produced by this substance applied as described resists chlorine and light in a great degree, the only change observed being the disposition to turn grayish under the influence of light, but it possesses a resistance comparable to that of indigo cuvé.

Pharmaceutical preparations, etc.

PHARMACEUTICAL PREPARATIONS, ESSENTIAL OILS, DRUGS, AND RAW MATERIALS FOR PHARMACY, ETC.

AUSTRIA.

AUSTRIA.

The chemical and pharmaceutical arts are in quite an advanced state in Austria, and have their principal seats of

Fumagalli, Monfalcone. production in and around the capital. G. B. Fumagalli, of Monfalcone, exhibited some pharmaceutical specialities, among which were a dentifrice called *anathérine*, colorless cod-liver oil "freed from stearine," etc.

Grohs, Vienna. F. A. Grohs, of Vienna, had a collection of nasal bougies, vaginal pessaries, and suppositories, which consist of gela-

tine impregnated with various therapeutic agents. He also showed oval and globular shaped masses of soft gelatine, properly medicated, for treating diseases of the ear. This mode of applying medicines has attracted considerable attention, and the products of this house are held in high esteem. AUSTRIA. *Pharmaceutical preparations.*

Jos. Lehmann, of Brünn, showed fine dried herbs and preparations made from them. He carries on a large industry, exporting great quantities to various parts of the world. Lehmann, Brünn.

W. Franz & Co., of Vienna, are a large general drug and chemical firm and warehousemen, employing about 60 workmen, and do a large export business in drugs, chemicals, essential oils, prepared herbs, and extracts. Franz & Co., Vienna.

Paul Rocca, of Triest, exhibited pills and other pharmaceutical preparations. Rocca, Trieste.

J. F. Kral, of Olmutz, had some metallic saecharates and liquid metallic soaps. Kral, Olmuts.

Essences, ethereal oils, and artificial fruit and liquor flavors were shown in abundance by Austrian exhibitors, and the specimens contributed by soap makers and perfumers give evidence that Vienna is a strong competitor of Paris in the production of toilet articles. *Essences, oils, and flavors.*

J. Pollak, of Vienna, had a handsome collection of fruit essences. Pollak, Vienna.

F. Klepetar & Co. exhibited a fine selection of natural and artificial essential oils and fruit essences, among which were two kinds of oil of fennel, one called *oleum fœniculi natur.*, described as being obtained by redistillation of the crude oil to separate it from the other, which is styled *oleum cœnieuli stearopt.* The latter heavier oil is said to correspond in softness of flavor and specific gravity to oil of anise, while it is much lower in price. The *oleum millefolii* has an intense blue color like that of German chamomile and is said to be substituted for the latter, which is very much higher in price than the former. Klepetar & Co. Oils of fennel

Russia-leather essence (oil of birch) was shown, as well as artificial oil of mustard (allyl isosulphocyanate), various compounds for the preparation of factitious liquors, and a series of artificial fruit essences. Oil of birch.

Haas & Rosenfeld, of Gaya, Moravia, contributed similar preparations. This house states that their production of oil of anise from native seeds was in 1877 5,000 kilos, of oil of fennel 3,500 kilos, 1,100 kilos of oil of carraway, etc. They also preserve large quantities of fruit juices pressed from the ripe fruits grown in the neighborhood. Experiments made on a sufficient scale and for some time have Haas & Rosenfeld, Gaya.

AUSTRIA.

Essences, oils, flavors, etc.

Haas & Rosenfeld.

Use of bisulphide of carbon.

demonstrated to Messrs. Haas & Rosenfeld that bisulphide of carbon cannot be successfully used for the extraction of essential oils from plants. A considerable loss of the menstruum is sustained; the same portion of it can only be used for extracting the same oils, since the solvent cannot be entirely freed from the oil it is used to extract; and finally it was found that oils extracted by its means always possessed the disagreeable odor of the menstruum.

Müller Bros., Brünn.

Müller Bros., of Brünn, exhibited essential oils in considerable variety.

Horowitz & Co., Brünn.

Horowitz & Co., also of Brünn, with a house in Vienna, showed a fine collection, consisting chiefly of essential oils, ethers, tinctures, and malt for brewers.

Moritz, Löw, Hussowitz.

Sal Schmidl, Misslitz.

Moritz Löw, of Hussowitz, and Sal Schmidl, of Misslitz, Moravia, both large producers of essential oils, were well represented in the Austrian section. The latter firm was about the first producer in Austria of this class of products for exportation, and the high repute gained in the earlier days of its existence is maintained. The amount of oil of carraway made by this fabricant is enormous, for he undertakes to supply "tourteaux de carvi" (carraway oil-cake) in any quantity for the fattening of swine, for which purpose it has been found to be wholesome and well adapted. It would be interesting to know if swine thus fattened yield a peculiarly flavored pork.

Carraway oil-cake for swine.

Ueberbacher, Bozen.

P. Ueberbacher, of Bozen, Tyrol, sent carraway oil, water, and liqueur made from the "wild" plant. In his collection were also found fine specimens of mountain honey, Alpine butter, beautiful Venice turpentine pitch for brewers, etc.

Demartini, Prague.

J. Demartini, of Prague, contributed purified wax and fats, poplar buds and fats impregnated with their preservative principle, and rose-water distilled from Bohemian roses.

Pongrátz, Son, & Co., Biala.

E. Pongrátz, Son, & Co., of Biala, Silesia, exhibited essences.

Prochaska.

F. Prochaska showed perfumes and toilet soaps.

Calderara & Blankmann.

Soaps, extracts, etc.

Calderara & Blankmann, among other excellent and handsome perfumes and toilet articles, showed a series of articles destined for toilet use, such as soaps, handkerchief extracts, toilet vinegar, cold cream, pomade, dentifrice, etc., impregnated with the essence of mugho pine, which not only communicates an agreeable odor, but at the same time it furnishes (according to Professor Kletzinski) by its oxidation a certain quantity of ozone, which serves as a disinfectant, antiseptic, and refreshing agent of no mean power.

AUSTRIA.

Gottlieb Taussig, of Vienna, made a remarkably pretty display of fine perfumery and toilet articles, among which his glycerine soap and hard soaps, molded and colored in imitation of fruits, lockets, etc., were especially worthy of note.

Essences, oils, extracts, etc. Taussig, Vienna.

The great factory of Sarg, Son, & Co. exhibited pure glycerine and fine soaps. This is one of the most important manufactories in Austria, and ranks among the first in Europe. It was founded by A. de Milly, in 1834, and was transferred to F. A. Sarg in 1858. The first glycerine was distilled on the Continent at this establishment in 1868, and crystallized glycerine was here prepared in 1872.

Sarg, Son, & Co. Glycerine and soaps.

A. Rösler, of Aussig, exhibited camphor from the only refinery of this product in the empire. The establishment, founded in 1877, refines about 100,000 kilos annually, and supplies the demand for that article throughout Austria and exports considerable quantities. The quality appears to be very good.

Rösler, Aussig. Camphor.

Natural and artificial mineral waters were exhibited by many establishments, of which there are about 80 in the empire.

Mineral waters.

BELGIUM.

BELGIUM.

Belgium sent very little to the Exposition that was of interest in a pharmaceutical point of view. Three or four firms sent specimens of hops, which were of good quality.

L. Cornélis, of Diest, exhibited bottles provided with desiccating stoppers, in which objects of every description may be indefinitely preserved in a state of absolute dryness. The flowers and other parts of plants which he had placed in these bottles were put there in 1874, and to-day it is almost impossible to distinguish them from those freshly cut. The device is perfectly successful for the purpose intended. The color and odors of the powdered drugs he exhibited are so well preserved that nothing is left to be desired. There were several small exhibits of pharmaceutical preparations, which do not call for special note.

Cornélis, Diest.

Dessicating stoppers.

Preservation of flowers, odors, etc.

CHINA.

CHINA.

China exhibited drugs and pharmaceutical preparations from sixteen cities. The whole number of specimens enumerated in its official catalogue as sent for display is 900, and these consist mainly of vegetable substances, for the Chinese seldom employ mineral remedies, and their therapeutic répertoire is almost wholly derived from the vegetable kingdom. The number of plants employed in the treat-

Drugs.

Vegetable remedies principally.

CHINA.

ment of the sick is immense. It may be said that almost every plant known in China, together with many obtained from other countries, are used as medicaments. They have a separate plant for every disease, and probably for every symptom. They also use several animal substances for the same purpose; for example, the gall of the bear, horns of the buck, gelatine from the skin of the Shantung ass, ambergris, bezoars of ruminants, which sell for their weight in gold, the bones, moustaches, and claws of the tiger—all of which are held in the highest esteem as therapeutic agents. Substances of the dirtiest and most disgusting nature are employed by them, one of which is a preparation presenting the appearace of button shellac. It is obtained by putting frogs (toads?) in a jar containing flour and irritating them with a stick; the secretion which exudes from their skins, under these painful circumstances, makes the flour sticky, and it agglutinates into a proper mass to be made up into the cakes above mentioned for use in medicine. The exhibits are well preserved and carefully labeled—in Chinese characters.

A plant for each disease and symptom.

Animal substances as remedies.

CANADA.

CANADA.

The Dominion of Canada was not well represented in Class 47. The few exhibits in this section, however, were very creditable to the chemists and pharmacists who made them.

J. Davids. J. Davids, Toronto, exhibited chemical products.

Lyman Bros. Lyman Bros., Toronto, sent a handsome collection of pharmaceutical preparations and chemicals.

W. Saunders. W. Saunders, London, Ontario, made a fine show of fluid extracts of medicinal plants and crude drugs.

H. J. Rose. H. J. Rose, Toronto, contributed chemical products. A fine collection of the indigenous plants of Canada were handsomely exhibited.

DENMARK.

DENMARK.

This country did not show anything of interest to the pharmaceutist.

FRANCE.

FRANCE.

Many of the French exhibitors had crude drugs and *matières premières* associated with their pharmaceutical preparations, but these specimens were mainly derived from the French colonies, whose contributions of raw material of almost every description and for nearly every art and industry were large, varied, and of great interest. The mother country displayed little else of her own production than the few following: Hops, of which she produces 4,400,000 kilos

Hops.

FRANCE.

per annum; olive oil, 24,225,801 kilos, valued at 37,791,661 fr.; resin (1874), 29,395,417 kilos, valued at 7½ millions of francs. Tan bark of French production, which is held in very high esteem not only in France but in other European countries, was exported in 1876 in the quantity of over 57 millions of kilos, and valued at nearly 15 million francs. Madder, saffron, and woad are the principal dye-stuffs grown in France, and their culture in 1874 occupied a superficies of 10,900 hectares. Since the discovery of an economical process for the manufacture of artificial alizarine the cultivation of the madder plant has been almost entirely abandoned. Honey and wax were produced in 1874, the former in the quantity of 9,851,496 kilos, of the value of 14,358,827 fr., the latter in 2,562,576 kilos, valued at 7,177,087 fr. Besides the hops produced at home, France consumed foreign hops to the value of about 14 millions of francs.

Hops, olive oil, resin.

Tan bark.

Madder, saffron, woad.

Honey and wax.

A number of most admirable specimens of dried vegetables, for use in medicine, were exhibited in this section, and the exhibits of corks and cork wood and of sponges were truly magnificent. Whole cork trees were placed in the galleries, and sponges *in situ* were shown, some attached to old vases and jugs, others to coral and shells, stones, and other objects, which rendered this collection doubly interesting and instructive. Some of them had been preserved in liquid before the soft animal matter had been removed, in which condition their appearance was anything but attractive. France imported sponges in the year 1876 to the amount of 257,878 kilos, of which about two-thirds were used in the country and one-third exported.

Dried vegetables.

Cork.

Sponges.

The cork industry in France appears to be increasing very much, for the importations of bark have risen since 1856 from 257,000 to 2,940,000 fr. in 1876, and the manufacture of corks is said to occupy the population of about forty parishes. Formerly a workman could make only 1,200 to 1,500 corks per day, but since the introduction of cork-cutting machinery 4,000 to 6,000 may be produced, according to size required. The various applications of this valuable material to its manifold uses are well and handsomely represented by several firms. Cork cutting by hand and by machine was carried on in and around the buildings in the neighborhood of the Algerian house on the slope of the Trocadéro.

Cork industry.

Cork machinery.

The manufacture of pharmaceutical preparations has assumed large proportions, and the products figure to no slight extent in the tables of exports. The annual value of the pharmaceutical products is estimated at $14,000,000,

Pharmaceutical products.

Annual value.

FRANCE.

and the manufactures are based chiefly on crude material imported from abroad. Pharmaceutical specialties are exported to the value of $1,900,000. The importation amounts to but $76,000. The general tendency of the pharmaceutical establishments is more and more to confine themselves each to the manufacture of a few certain specialities on a large scale. The constantly growing interests centered in the manufactories of perfumes at Paris have given a powerful impetus to several branches of industry, such as flower farming, the preparation of essential oils, the finer oils, and fats, etc. The exhibition was imposing in its extent and tasteful arrangement, and was admirably supplemented by the enormous and finely classified exhibit of native products from the French colonies. One of the most extensive and complete displays was that of the French mineral waters in a special pavilion. Forty-five departments in France possess mineral waters, and the 107 leading springs yield a daily supply of 63,000,000 liters, divided as follows, according to their leading constituents:

Pharmaceutical products.

Specialities.

Perfumes.

Mineral waters.

Character of springs.		Liters.
	Sulphur springs	23,370,000
	Carbonic acid	16,146,000
	Chlorides	13,050,000
	Sulphates	10,050,000
	Iron	384,000
		63,000,000

The pharmaceutical preparations exhibited in the French section presented a fine appearance and lead the observer to place a high estimate on their claims for great distinction; and although some exhibitors may have enhanced the apparent value of their products by meretricious means, still many of them give evidence of the considerable progress that is being made in the practice of "elegant pharmacy." This art is not altogether unknown in our country, where it is looked on by the progressive party as an evidence of a steady progress in pharmacy, and it is hailed alike by doctor, apothecary, and patient; yet it appears that this progress must be had by the withdrawal of the manufacturing processes more and more from the hands of the apothecary, and bring him ultimately down to the level of the mere retailer of articles made by others. There can be no doubt that pharmaceutical preparations, like other products of manufacturing industry, may be produced by means of superior apparatus and special skill, acquired in the constant performance of a few operations, of better quality, more sightly appearance, and at greatly reduced prices, than can be

High character of the French pharmaceutical exhibit.

Elegant pharmacy.

FRANCE.

turned out in the old way. Apropos of this subject, the "London Pharmaceutical Journal and Transactions" says:

Elegant pharmacy.

"Recognizing the extent to which this class of business [referring to the growth of 'elegant pharmacy'] has developed in the last few years, the inquiry naturally arises whether the time is not coming when the practice of dispensing by the pharmacist will become exceptional and when his ordinary occupation will be the simple retailing of already compounded medicines. If this be found to accord with the public good and public convenience, there will be little use in protesting against it or lamenting over it, and the pharmacist would no doubt show his business skill by accommodating himself to the altered circumstances. But there is one consideration that will have always to be borne in mind, important alike to the medical man, pharmacist, and patient, and that is, the dependence of the reputation of the two former and the health of the latter upon these articles being truly what they are represented to be. There is no intention to suggest any imputation, but simply to record a note of warning, in recalling the fact that four years ago a committee reported to the American Pharmaceutical Association that competition had so far developed the art of elegant pharmacy in the United States that not only the physical characters of taste and smell of powerful drugs, but the actual presence of the drugs themselves, in some preparations examined, had defied detection. Such a possibility will always help to make the new system somewhat repugnant to the instincts of the true pharmacist, notwithstanding some undoubted advantages it presents, so that although he may guard himself as much as possible by dealing only with makers of established reputation, and bringing his scientific skill to bear in testing the honesty of their preparations, his feelings will still often be expressed by the couplet—

Tendency to supersede the dispensing of drugs by pharmacists.

Tendency to adulteration and fraud in the preparations on the market.

"'The reason why I cannot tell,
I do not like thee, Dr. Fell.'

"However the causes may be explained, and whatever may be the consequence, a visit to the pharmaceutical courts of the present Exhibition in Paris makes manifest two facts of great importance in relation to the future of pharmacy, and these are the marked tendency in the present day to the accumulation of the preparation of medicine in the hands of fewer persons, and of these, unfortunately, taking into consideration the large class of proprietary medicines, a considerable proportion have no pretensions to the name of pharmacist."

Proprietary medicines.

Flower farms and perfumes.

The cultivation of flowers and the extraction of their oils for the manufacture of perfumes have long ago rendered France famous, where this industry has almost been elevated to the position of one of the fine arts.

Chiris, Lautier, Roure-Bertrand fils, Court, of Grasse, Ulpes Maritimes.

Handsome exhibits were made by the houses of Chiris, Lautier Fils, Roure-Bertrand Fils, and Court, all of which are from Grasse, and whose exhibits consist mainly of promades saturated with the odorous principles of flowers, for use as *matières premières* for the manufacturer of perfumes and other toilet articles, an industry of great magnitude, which has its principal seat at Paris. The importance of this industry may be inferred from the following statistics: During the first 20 years of the present century

FRANCE.

Flower farms and perfumery.

the annual production of perfumer's articles amounted to 4,000,000 fr.; the business increased to 1866, when the exports amounted to 16,000,000 fr. and the home consumption to 10,000,000 fr. more; in 1876 the exports were 17,000,000 fr. England is the largest customer France has for this class of products, and the following countries, in the order in which they are named, take rank: Belgium, Spanish America, Brazil, Germany, United States, etc.

Exports.

Hanart, Anzin.

E. A. Hanart, of Anzin, showed very superior oils from labiate plants; he describes the cultivation of peppermint and the manufacture of the oil. The plant is harvested in full sunshine during the month of May, put up in little shocks, and allowed to remain in the field for several days. It is then brought in, carefully freed from all foreign herbs, and the entire plants are placed in the stills, which are about 66 gallons, capacity, and heated by steam circulating around a jacket and through spirals. To avoid the production of an herbaceous taste, the distillation is carried on as rapidly as possible. The yield is $\frac{1}{500}$th part and the product, which has a greenish-yellow color, possesses a highly agreeable piquant odor. The crude oil is purified by several washings with cold water, and by exposure to the air during some weeks in a cool, dark place. After this it is rectified and kept in bottles secluded from air and light for some years before being offered for sale, when it is said to rival the celebrated English oil both as to quality and in price.

Peppermint oil.

Distillation.

Purification.

Rectification.

Robertet, Paris.

Saujot & Foucher.

Roure-Bertrand fils.

Chardin & Massignon.

The house of Robertet, of Paris, sent a specimen of solid oil of roses. That of Saujot & Foucher, also of Paris, showed a fine specimen of concrete oil of orris. Roure-Bertrand Fils exhibited vaseline as a vehicle for odors, and Chardin & Massignon, of Paris, have applied paraffine to the same purpose. There were upwards of a hundred exhibits of perfumes and kindred articles from Paris, and they all bore the appearance of finish in the highest style of the art.

Pharmaceutists.

The pharmaceutists, like the perfumers, are to be numbered by hundreds, and they nearly all make very fine and diversified displays of chemical and galenical preparations, but many exhibitors have specialties in their vitrines, the nature and qualities of which can only be guessed at.

Adrian & Co., Paris.

The house of Adrian & Co., of Paris, established in 1872, employs 120 operators, who manufacture a full line of very handsome chemicals for pharmacy, photography, etc. They exhibited resin of scammony of nearly perfect whiteness, exceedingly beautiful specimens of crystallized digitaline, daturine, atropine, the salts of pilocarpine, etc. The establish-

FRANCE.

Pharmaceutists.

ment is a model pharmaceutical laboratory, provided with all the modern appliances for the economical preparat on of chemicals, pharmaceutical products, such as alkaloids and their salts, chloroform, ethers, extracts, powders, pills, ointments, pastiles, capsules, apothecary's confectionery, etc. It has attached to it a complete laboratory mounted for chemical analysis and research, which is open to members of the medical and pharmaceutical professions. There is another feature connected with this manufactory which is of great convenience and advantage to the pharmacists of Paris and its environs. Its perfected apparatus and machinery are placed at the disposition of those who choose to superintend the fabrication of their own preparations.

Adrian & Co.

Laboratory.

Mouysset and Darasse & Co., of Paris, and Grandval, of Reims, as well as Adrian & Co., exhibited extracts made by a special process. They present a light color, a frothy, porous, crispy structure, and appear to be dry and non-hygroscopic. They are said to be made in vacuo, freed from chlorophyll, and possess the therapeutical qualities of their plants in a high degree. Some of these extracts are shown by Darasse dissolved and dried on glass dishes, on which they appear transparent like varnish.

Mouysset; Darasse & Co.; Grandval; Adrian & Co.

Non-hygroscopic, dry, porous extracts.

Loret, of Sedan, exhibited extracts prepared from fresh narcotic plants, freed entirely from such matters as chlorophyll, starch, albumen, and fatty matters; they are said to be very permanent and thoroughly reliable.

Loret, Sedan.

Grandval and Mouysset exhibited saccharated extracts which, when diluted with a proper proportion of sirup, form the medicated sirups of the codex.

Saccharated extracts.

Armet de Lisle & Co., of Nogent-sur-Marne, displayed a large collection of the salts of cinchona alkaloids. This house is the successor of Pelletier, the discoverer of quinine, and the products made by it sustain the highest reputation. The amount of Peruvian bark worked up at this establishment is said to exceed 1,000,000 kilos, and 12,000 kilos of sulphate of quinine are extracted annually, 10,000 of which are exported. Other manufacturers of quinine and its salts are Taillandier, of Argenteuil, near Paris, and Dubosc & Co., of Paris, who showed fine specimens of their products. Amorphous quinine was contributed by Perret and by Limousin, of Paris. E. Beau, of Alais, had a case containing preparations of antimony, and E. Bellat, of Rouen, sent ethers, chloroform, chloral, tannin, etc. Phenol and its derivatives for hypodermic use were contributed by Déclat & Co., of Paris. Delpech & Co, of Paris, showed a large number of preparations of cubebs and eucalyptus, and Desnoix

Pelletier.

Cinchona alkaloids.

Sulphate of quinine.

Amorphous quinine.

Antimony, ethers, tannin, etc.

Phenol and derivatives.

Cubebs and eucalyptus.

FRANCE.

Pharmaceutists.

& Co., of Paris, exhibited, among their pharmaceutical preparations, hematosine, and a cross, weighing 20 grains, made of iron extracted from blood. Fumouze Frères, of Paris, along with their famous "Vesicatoire d'Albespeyre, had a fine specimen of pure cantharidine, and the Spanish fly preserved for ten years in an atmosphere of bisulphide of carbon. A number of compounds of cantharidine, with the alkalies and metallic oxides, were also exhibited in this case by M. Beguin, who also prepares a plaster having caoutchouc for its basis.

Hematosine.

Cantharidine.

Digitaline. Nattivelle. Blaquart.

M. Nattivelle, who first produced digitaline in a crystallized state, exhibited some handsome specimens; and M. Bloquart, the successor of Homolle & Querenne, besides digitaline in well-defined crystals, showed a capsule containing the substance in an amorphous state, bordered by a fringe of feathery crystals, indicative either of a process of transformation or that there are really two bodies, one crystallizable, the other not, and that the former is crystallizing out from a mixture.

Moreaux. Atropine. Daturine.

Narceine.

Moreaux, of Anizy-le-Château, exhibited fine specimens of atropine and daturine and their salts, and some bromohydrate of conicine. Narceine and some galenical preparations made from it were found in the case of M. Gigon, of Rue Rambuteau, Paris. Montreuil Frères, of Clichy-la-Garenne, have an excellent collection of drugs, among which are a calabash of curare, specimen of curarine, and some magnificent crystals of iodide of cadmium; and Helain, of Paris, a large assortment of powdered drugs. The most attractive displays of fine chemicals in the building were those made by Billault & Billaudot.

Curarine.

Billault & Billaudot.

C. Hoffmann.

C. Hoffmann, Dubosc & Co., and Dorvault & Co. (Pharmacie Centrale de France), all of Paris: The firm first named had an exhibit of rare and beautiful chemicals, which merited the term magnificent, and was, perhaps, the finest display of the chemist's art which has ever been made. An enthusiastic chemist has described, in a few words, this *chef d'œuvre* of the French section:

Magnificent exhibit of the chemist's art.

"The bed of the case is covered with crystallized bismuth, the splendid iridescence of which demonstrates that the secret of preparing this is not lost, as has been reported. Grouped above this are a large number of beautiful chemicals, among which may be mentioned crystallized glucose, crystallized dambonite (caoutchouc sugar), and crystallized mannite; leucine from albumen, tyrosine from fibrine, and alantine from fibrine, in white crystalline flakes. Then there is a specimen of erythrite, or erythromannite, in transparent crystals, sparkling like so many diamonds, and another in well-formed crystals nearly as large as a man's fist; also sublimed alizarine in needles almost an inch long, and sublimed indigatine in large fine crystals, resembling those of perman-

ganate of potash. Sulphate of cadmium appears in wonderfully perfect large white rhombic prisms, and is accompanied by some fine iodide of cadmium; silicon is also there in steel-gray crystals. But one of the most exquisite collections in this case is a group of platino-cyanides, not only because of their beautiful appearance, but for the interesting illustration they afford of the polymorphism (polychroism?) of these compounds. Then the yttrium platino-cyanide is in dichroic red and green crystals; whilst the potassium platino-cyanide forms crystals of a rich copper-bronze color, to which the double platino-cyanide of potassium and sodium affords a vivid contrast, its crystals being of a bright yellow with a purplish tinge."

C. Hoffmann.

Tannin.

A specialty of this house is the preparation of tannin, of which they manufactured, by improved process and apparatus, in 1876, 60,000 lbs., of which two-thirds were exported to Russia, where it is used for the tanning of hides. During the same period it produced 4,000 lbs. of gallic acid, more than one-half of which was consumed in the preparation of pyrogallic acid.

Gallic acid.

Chlorate of baryta.

Chlorate of baryta was produced in the amount of 4,000 lbs. Ten thousand pounds tartar-emetic are annually produced. Twenty thousand boxes of phosphide of calcium were prepared for the government for the self-luminous safety buoys lately introduced into the French marine service.

Tartar-emetic.

Phosphide of calcium for safety buoys.

Fine collection of the rarer metals, alkaloids, etc.

The house of C. Hoffmann exhibited, among many fine specimens of chemicals, including a collection of the rarer metals, a number of alkaloids and kindred bodies and several synthetical organic products. Worthy of mention were noticed éserine and its salts, atropine, digitaline, an immense display of splendidly crystallized caffeine, a good show of morphine salts with the allied bodies, meconine, codeine, thebaine; also paracotoin, kamaline, elaterine, menispermine, and a superb specimen of what is rarely seen, namely, white crystallized hyoscyamine; a vase containing a fascicle of long crystals of phthalic anhydride, a substance recently sprung into great importance as a factor in the production of the new and ravishing resorcine colors. An interesting collection of educts and products derived from the animal secretions were among the collections of M. Hoffmann.

Dorvault & Co.

Pharmaceutical confectionary.

The Pharmacie Centrale de France (Dorvault & Co.) is perhaps the most extensive manufactory of the multitude of chemical pharmaceutical confectionery and semi-proprietary articles used by apothecaries in France. Formerly it had its sole seat in the city of Paris, not far from the Hotel de Ville, but some years ago the company purchased the drug-powdering mills of M. Menier (the famous chocolate manufacturer), at St. Denis, and have extended and im-

FRANCE.

Pharmaceutists.

proved the property until it is to-day a very large and thoroughly equipped chemical works, turning out annually a large and varied product of chemical and galenical preparations. Their exhibit consisted, among many other substances, of a jar of a hundredweight or so of large and handsome crystals of strychnine; a half a hundredweight of hydrate of chloral in the form of a sphere; specimens of rare metals, lithium for example; a good specimen of herapathite; racemic acid; alkaloids and their salts, such as quinine, pilocarpine, igasurine, atropine, jalap, and scammony resins nearly free from color.

Dorvault & Co.

Strychnine.

Rare metals, Lithium, Alkaloids.

De Laire & Co.

Vanilline.

De Laire & Co. exhibited an interesting specimen of artificial vanilline, prepared synthetically, which diffused its grateful odor for some distance around. They had also sugar aromatized with it and a preparation styled "*dragees à la vanilline.*" The method of preparing this body will be described in another place; but it may be noticed here that Haas & Rosenfeld, manufacturers on a large scale of essential oils and artificial flavoring essences, have stated, as the result of their experience, that artificial vanilline is quite useless in the flavoring of liqueurs, etc., but that it may find its place as an odor in the art of perfumery.

E. Perret.

Pepsine, etc.

E. Perret, Paris, showed pepsin and pancreatine preparations, diastase, bromide of camphor, and crude quinium from Losca bark.

Rigaud & Dusart.

Rigaud & Dusart, successors of Grimault & Co., are manufacturers of a number of specialties in the way of elegant pharmaceutical preparations, which have obtained a large share of public patronage in various countries. The fabrique gives employment to 150 operatives and turns out annually 3,000,000 francs' worth of produce. They exhibited handsome *perles*, capsules, pills, pastiles, *dragées*, granules, sirups, *essences de matico*, and *de boldo*, *de santal*, *de sassafras*, etc.; the distillations of the essences being effected by a new process, in which a "double current of steam" is claimed to give much better results than has heretofore been obtained. They had also in their vitrine cannabine, guaranine, etc., as well as pepsin and pancreatine preparations. Their wares are characterized by great neatness, taste, and finish of their envelopes. Methylic, amylic, ethylic chlorals and Lecontés alcoholate of chloral were shown by this house, and propylic chloral was exhibited by M. Torchon, of Paris, who had some singular specimens amongst his chemicals; they were a rat and a cock preserved since 1871 by the antiseptic power of a ten per cent. solution of chloral injected into their veins.

Production.

Capsules, pastiles, sirups, essences.

Pepsin, pancreatine, etc.

Chlorals.

FRANCE.

Pharmaceutists.

Schlumberger & Cerckel were among the few who exhibited specimens of the highly praised salicylic acid and its many preparations; numerous compounds were shown, such as the pure acid in the amorphous form, as well as in a crystallized and sublimed state, and its salts with potassium, ammonium, zinc, magnesium, lithium, quinine, morphine, copper, and lead. The lithium salt is said to be quite efficacious in the treatment of some forms of rheumatism, gout, and calculous diseases.

Schlumberger & Cerckel.

Salicylic acid and its salts.

Poulenc & Wittmann.

Poulenc & Wittmann, Paris, had a fine display of permanganate of potassa in very large and long crystals; lactates, formates, nitro-prusside of sodium, iodine, glycerine, and many other handsome chemicals used in pharmacy.

Bloquart.

Querenne's iron.

Querenne's iron was shown by M. Bloquart, in the form of a very fine, light, slate-gray powder, absolutely free from sulphur, which was evidenced by the non-coloration of lead water by a stream of gas, produced by the action of diluted hydrochloric acid on a portion of the reduced iron, and passed through the solution of lead salt.

Fer hématique Michel.

Fer hématique Michel, consisting of a phosphate of iron and phosphate of sodium dissolved in water rendered alkaline with soda, was exhibited as a preparation representing the form in which iron exists in the blood.

L. Jolly. Phosphates of iron.

The blue phosphate of iron (ferroso-ferric phosphate) and the green and the white phosphates (ferric phosphate) were exhibited by L. Jolly, of Paris, who claims to have obtained a phosphate of iron as an educt from the blood. He seems to have devoted much time and attention to the study of the actual condition or state of combination of the iron in the blood, and republishes some of his memoirs that have been presented to the various scientific societies of Paris. One of these, entitled "*Recherches sur la constitution chimique des globules sanguins*," claims in substance that iron exists in the blood globules in the state of tribasic phosphate. He also states that iron does not, as is generally affirmed, form an integral part of the coloring matter of blood, and this he thinks he demonstrates by exhibiting a chloroformic solution of the hematic pigment, free from iron, and he subsequently gave a method for extracting the phosphate of iron from blood, and among the exhibits was a quantity of it obtained from bullock's blood by means of the process described. This fundamental physiological research of M. Jolly, if it proves to be trustworthy, reflects great credit on pharmacy.

Condition of iron in the blood.

Boudalt's pepsin.

Boudalt's pepsin was exhibited in many forms by Hottot & Co. Chassaing & Co. and M. Perret had pepsin, sep-

FRANCE.

Pharmaceutists.

Elixir cupeptique. Pepsin-diastase, etc.

arately and a compound called pepsin-diastase among their exhibits. M. Tisy showed an "elixir cupeptique," which is said to contain 0.10 grams of pancreatine, 0.30 grams of diastase, and 0.10 grams of pepsin to the spoonful, while M. Catillon had a preparation of pepsin containing cinchona, iron, wine, and glycerine.

Peptones, or digested food.

The pharmaceutists of France and of other European states have not limited themselves to the separation of pepsin, pancreatine, and diastase as aids to digestion, but they have gone extensively into the preparation of digested food, under the forms of peptones, for the invalid.

Defresne, on digestive principles.

M. Defresne, who has made a study of digestive principles, has laid a report before the Academy, in which he claims to have isolated three distinct "ferments," and has named one *myopsine*, capable of digesting 104 times its weight of dry albumen, but without action on fat or starch; another he calls *steaopsine*, capable of breaking up 24 times its weight of fat without acting on starch; and a third, *amylopsine*, not affecting fat, but capable of converting 25 times its weight of starch into glucose. He makes another important observation, which is that the pancreatic juice is not identical in different genera of animals, but attains its maximum power upon albumen—*i. e.*, contains most myopsine—in the omniveræ, whilst in the ruminantiæ it is almost without action on albumen. As proof of the power of his digestive agent he exhibits the skeleton of a turkey, originally weighing about 17 lbs., floating in a yellowish fluid, the flesh of which was entirely dissolved (digested) by means of his pancreatine mixed with warm water, into which the whole turkey was put immediately after it was killed and "dressed." He also shows glucose resulting from the conversion of starch by means of amylopsine and cod-liver oil, which has been emulsified or digested by pancreatine.

Myopsine.

Steaopsine.

Amylopsine.

Action of pancreatine on flesh.

On starch.

Dr. Henninger on peptones.

In regard to peptones, Dr. Henninger, a distinguished young chemist of Paris, in a late work on the nature and physiological rôle of peptones, says he has found that the peptones derived from fibrine, albumen, or caseine, when freed from mineral matter, all appear as white, amorphous, infusible powders, very soluble in water and in glacial acetic acid. They react slightly acid, and behave like feebly acid amides. When an acetic solution of a peptone is treated with sulphuric, hydrochloric, or nitric acid, a plentiful white precipitate is immediately formed, and collects into a nearly colorless viscous mass, soluble in water. This he looks upon as a salt of peptone, corresponding to the

Behavior of acetic solutions of peptones.

acid employed. No difference could be detected in the behavior of peptones from various sources towards reagents, all having certain characters in common with albuminoid matters, but less tendency to coagulation and precipitation. They approach closely to gelatine, but their hot solutions do not gelatinize on cooling. Peptones, although apparently identical in their chemical properties, differ, like the albuminoid matters from which they are derived, in their effect on polarized light, the rotatory power of albumen-peptone being the weakest and that of caseine-peptone the strongest.

Pharmaceutists.

Peptones.

FRENCH COLONIES.

The collection of crude drugs sent to the Exposition from Algeria and the French colonies was very large and varied, well arranged, distinctly labeled, and to the student of natural history was exceedingly interesting. Its value was greatly enhanced by a thorough and systematic catalogue which the commissioner had prepared. This exhibit was certainly one of the best in the building, and, coming from all parts of the world, served to give at a glance a general and comprehensive view of nearly the whole vegetable *materia medica.*

Large collection of crude drugs.

French Guiana sent a great number of medicinal plants and other crude materials for pharmacy, among which may be mentioned citrate of lime, prepared from the juice of the lime, which grows abundantly in that country; curari poison and arrows poisoned with it; grains of paradise; copaiba; *Pareira brava*, and a yellow *Pareira brava*, which is recommended only for obstructions of the liver; simaruba, and *Quassia amara.* There was exhibited from this colony a wood, the infusion or decoction of which is reputed to be strongly aphrodisiac. Oil of boa-constrictor, a remedy for pains, etc., was contributed by the central committee. Tonqua bean and *Vanilla pompona* were among the articles used in perfumery.

French Guiana.

Martinique sent a great variety of drugs, principally derived from the vegetable kingdom, some mineral waters, and a few articles useful in the art of perfumery. Cinchona barks were exhibited, and it is said that the Peruvian cinchonas, rich in quinine, may be successfully raised on the high lands. Among the many plants exhibited was the *Cassia occidentalis*, the seeds of which, when roasted, are said to form the best known substitute for coffee, so that if mixed with ground coffee in a proportion no greater than one-fifth it is impossible to detect it either by sight or taste.

Martinique.

Cinchona barks.

FRENCH COLONIES.

Guadeloupe.

From Guadeloupe the principal article in the line of drugs was vanilla, which, besides sugar and Campeachy dye-wood, is the largest export from that island.

St. Pierre and Miquelon.

The Isles of St. Pierre and Miquelon sent only such crude articles as are common in the United States and Canada. A variety of *Sarracenia*, in great repute as an abortive and remedy for small-pox, was exhibited, as well as *Gaultheria procumbens*, *Coptis trif.*, and *Abies canad.*, the young twigs of the latter being used in the fabrication of "spruce" beer and for tonic baths.

Senegal.

Ground-nuts and gums.

From Senegal the items of largest export are, as given in the official reports for 1876, ground-nuts (*Arachides*), 24,000,000 kilos; gum senegal (of all descriptions), 2,486,395 kilos; and of caoutchouc an amount valued at 537,382 fr. Vettiver is exhibited by Lenormand, of Saint Louis.

Gaboon.

Poisonous vegetable agents.

Gaboon contributed many vegetables possessed of very poisonous properties, and which no doubt will yield valuable therapeutic agents when they are thoroughly studied. Among these may be noted *Strophantus hispidus; ilango*, a plant belonging to the *Orchidaceæ; icaja*, from a species of *Strychnos; atchimé*, from a species of *Ignatia; okanyago* and calabar leaves (*Physostigma venenosum*). *Ourendé* is said to be powerfully aphrodisiac. *Physostigma ven.* and its alkaloid, *éserine*, have been described, and are now employed as valuable therapeutic agents by the medical profession in most countries, and need no further notice in this place; but the *Strophantus hisp.*, the *Erythrophleum guinsense*, the *atchimé*, and the *icaja* deserve more than a passing notice.

Strophantus.

Preparation.

The common name of the *Strophantus* is *inée* or *onaye*. It is a climbing plant, belonging to the family *Apocynaceæ*, and yields a seed which contains a crystallizable principle endowed with powerful toxic properties. This principle, which is called *strophantine*, is obtained from the crushed seeds by extraction with cold alcohol of 90°, which is got rid of by careful evaporation. The resulting extractive matter is exhausted with cold water, which after filtration is concentrated until on cooling crystals appear. These are to be purified by a second crystallization. They form quadrilateral plates, derived from the orthorhombic prism, and their solution deviates feebly the ray of polarized light to the left. They are soluble in water and alcohol and slightly or not at all soluble in ether and chloroform. To test-paper the crystals are neutral and do not give reactions characteristic of the alkaloids.

Toxic action.

Cardiac poison.

It is powerfully poisonous and produces death by arresting the action of the heart, the nervous system and muscles maintaining their activity for some time

after the heart has ceased to beat. An alkaloid called *inéine* has been extracted from the appendages of the seeds of this plant, which does not seem to be capable of paralyzing the action of the heart as strophantine has been observed to do.

FRENCH COLONIES.

Gaboon.

Erythrophleum guinsense, a leguminous plant belonging to the tribe *Mimosæ*, known by the common name *manǫ̀ne* or *bourane*, yields a bark (*sassy* bark) which the natives of the west coast of Africa employ for the purpose of preparing an extract with which they poison their arrows. It has been known for many years, and quite recently Drs. Gallois and Hardy, of Paris, have investigated the bark of the tree chemically and discovered in it an alkaloidal body of most energetic poisonous properties, which they name *erythrophléine*. It is extracted from the powdered bark by a process similar to that employed by Stas for the separation of alkaloids. The chemical reactions of this body resemble in some respects those of strychnine, but it has not been sufficiently studied to enable its characteristic properties to be distinctly laid down. It has been proved to be a strong cardiac poison, the action of the heart being speedily arrested by it, while the other muscles of the body retain their irritability for hours after the arrest of the action of the central organ.

Erythrophleum guinsense.

Arrow-poisoning preparation.

Process.

Cardiac poison.

Icaja, a shrub called *m'bondon* or *bondon*, and belonging to the family of the *Loganaceæ*, furnishes the ordeal poison employed by the natives about Cape Lopez. An alkaloid has been extracted from the bark of this plant by Frazer, and Drs. Gallois and Hardy have also established the presence of a poisonous principle in it, whose action is said to be similar to that of strychnia. All these substances have been obtained in such small quantities that the investigators have not been able yet to pursue their researches to a point definite enough to warrant an absolute statement as to their real chemical properties or their physiological or toxicological effects.

Icaja.

Ordeal poison.

Algeria made an extensive and fine display of drugs, tanning and dyeing materials, all handsomely arranged in a special Algerian building situated in the Trocadéro inclosure. *Eucalyptus globulus*, Spanish pellitory, colocynth, squill, *Thapsia silphium* are among the most noteworthy of the exhibits of medicinal drugs. The only specimen of the "*ergot du diss*" in the Exposition found a place in this collection. Apparently the most important substance of a medicinal nature exhibited in the Algerian section is the *bounafa resin*, which is the local name of the great panacea of the North African Arabs for *Thapsia* resin, much of which

Algeria.

Handsome display of drugs, tanning and dyeing materials.

Thapsia resin.

FRENCH COLONIES.

Algeria.

is exhibited, along with an apparatus used for its preparation. Several French houses have taken up this resin as the material for a revulsive plaster, and there is a fair chance that it may succeed as a popular remedy. Fronds of the *Lecanora esculenta* are exhibited, which are not only curious on account of their singular appearance, but interesting on

Manna plant.

account of the supposed identity of the plant with that which furnished the manna of the Scriptures. It is said to be now used as a substitute for wheat when that cereal is scarce, or rather to mix with it as a diluent, for its nutritive power cannot be very great, since oxalate of lime constitutes

Eucalyptus.

two-thirds of its weight. Eucalyptus was shown in all its forms; leaves, bark, oil, essence, tincture, wine, sirup, liquor, lotion, pills, cigarettes, etc., occupy a conspicuous position. Eucalyptol is the active medicinal agent of the plant, but another principle, eucalyptic acid, has been found to exist in some abundance in the *E. rostrata*, and is supposed to be the agent in the timber from that tree which protects it from from the attacks of the *Teredo navalis*.

Cork.

Corks and cork wood are among the largest items of export from Algeria. In 1876 the figures were 5,223,000 fr. while barks for tanning purposes were shipped to the amount

Sponge.

of 19,046 tons, valued at 3,809,000 fr. Sponges are said to be found on the coasts, of a fineness and quality comparble with those from Syrian waters.

Réunion.

Vanilla.

From the Isle of Réunion vanilla was the most interesting article exhibited, and since this perfume has grown to be of such importance in the three arts of pharmacy, perfumery, and confectionery, it would not be uninteresting to know how the French nation foster its cultivation. It is stated by a late writer—the reporter for the "Pharmaceutical Journal and Transactions"—that in 1849 only 3 kilos

Increase of exports and reduction of price.

were exported from this island, but in 1876 the exports amounted to 27,759 kilos, and that the price has fallen from 500 fr. the kilo to 32 fr. The average price, however, for a a prime article is from 50 to 100 fr. the kilo. The cultiva-

Exhaustive crop.

tion of this plant is attended with great exhaustion of the soil, taking from each hectare in seven years 932 kilos of potassium and 1,350 kilos of phosphoric acid, besides considerable lime and magnesia. This impoverishment of the soil, and the subsequent prolonged artificial fertility thereby necessitated, weakened the plants very much, so they frequently showed symptoms of blanching, which was followed by the attacks of destructive parasites such as *Bacterium putredinis*, etc. Fresh plants were obtained from Mexico, apropriate manure was used, and a plan of pruning adop-

ted, so that the plantations now present a healthy appearance and produce freely. Another plant grows in abundance on this island which possesses an odor between that of vanilla and tonqua. This plant is the *Angræcum fragrans*. FRENCH COLONIES. Réunion.

From the islands of Saint Marie, Nossi-Bé, and Tahiti nothing of special importance is to be noted, except, perhaps, that the last-named sends specimens of *Piper methysticum*, the root of which is capable of yielding a large quantity of alcohol, and Tahiti arrow-root, yellow sandal-wood, tonqua and vanilla beans. Saint Marie, Nossi-Bé, Tahiti.

From New Caledonia large and fine specimens of nickeliferous minerals are sent, as well as ores of iron, chromium, cobalt, manganese, copper, etc. New Caledonia. Ores.

From French Cochin China a great many drugs were exhibited, none of which were at all new, except a variety of gelose called *thao*, and imported as Chinese or Japanese isinglass. This substance is made from sea-weed, and possesses properties which make it interesting to the student and valuable in the industrial arts. It is used in the place of starch, gum, and the usual dressing for textile fabrics—all of which it will supersede if the accounts of it are true. M. Heilmann, of Rouen, says that 1 part of *thao* to 100 of water produces a dressing which is supple and strong, and gives substance rather than stiffness, while dextrine, like starch, makes the tissue drier and harder, and gives less facing to thread. The addition of a little glycerine to it gives a dressing still more flexible and soft, and while rendering the tissues less stiff and harsh, it communicates more "body" to them. M. Gantillon, of Lyon, says that, once dissolved, *thao* will mix while hot with any gum, dextrine, starch, or gelatine. The principal advantage of this substance in dressing silk fabrics is that while preserving their suppleness it gives them greater glossiness and makes them softer to the touch. The mixture of *thao* with tragacanth is said to be the best method of using it. One remarkable advantage *thao* has over other dressings is that as it is soluble only at a high temperature, a moist atmosphere, fog, or even rain does not affect the material dressed with it. This substance has the power of making a stiff jelly with 100 times its weight of water. Cochin China. *Thao*: gelose from sea-weed. Its value and uses. Dressing for fabrics.

From French India, Pondicherry sent a good exhibit of Indian products, consisting of coloring and tanning materials, gums, resins, oils, insinglass, and some raw materials for perfumery, none of which are very new or require special mention. Pondicherry.

GREAT BRITAIN AND IRELAND.

GREAT BRITAIN AND IRELAND.

This kingdom being essentially a manufacturing country, no exhibits of crude drugs were to be seen except those shown by Baiss Bros. & Co. and Gidney, Clark, & Co., both of London. The former had a case containing a good assortment of crude and powdered drugs, and the latter many handsome specimens of resins collected from different parts of the world.

But few crude drugs exhibited.

Interesting exhibits from British colonies.

The exhibits from English colonies, however, like the French colonies, were numerous, rich, and very interesting. The novel and most striking of them were various species of *Eucalyptus* from Australia; a perfume from the *Acacia pycnantha* from Victoria, said to diffuse a delicious odor; and dried bark of *Acacia decurrens* from Queensland, yielding from 18 to 33 per cent. of tannin. This tree is very abundant and widely distributed, and the catechu may be made from it at a cheap rate. A fine collection of crude drugs was exhibited by W. Saunders, of London, Ontario. British Guiana sent tonqua beans, wourali poison, copaiba, oil of *Onodaphne opifera*—a solvent of india-rubber,—a variety of gutta-percha called *balata*, a substance which on account of its low price and valuable properties will no doubt come into general use for many industrial purposes.

Eucalyptus.

Acacia.

Saunders, Ontario.

Balata.

India and Ceylon.

British India and Ceylon, sent among other and numerous specimens of crude drugs, specimens of cultivated cinchona bark, as *Cinchona calisaya*, *anglica*, and *josephina*, as well as graphite, cinnamon, vanilla, vitivert, and cardamoms. No small degree of interest was attached to the very complete display of natural products from the numerous colonies of Great Britain, which, coming as they did from every division of the globe, contained representatives of nearly all the raw materials required by the druggist and chemist.

Cinchonas, graphite, and spices.

Excellent exhibit of pharmaceutical preparations.

The pharmaceutical preparations and chemicals used in medicine were well represented, and the show made by British exhibitors was scarcely inferior to that made by the French, and in some respects it was superior to any in the Exposition.

Burgoyne, Burbridges & Co.

Burgoyne, Burbridges, & Co. exhibited a handsome collection of pure chemical and pharmaceutical products, among which were noticed very fine scale preparations.

Bush & Co.

Bush & Co., of London, had a good display of the same class of medicines, together with fruit essences, essential oils, citrates of lithia and potash, and many granular salts.

Pharmaceutists.

Atkinson & Co., of London, sent a fine exhibit of essential oils, camphor, alkaline iodides and bromides, preparations of mercury, salts of cadmium, and vermilion.

Atkinson & Co.

The first specimen of capsaicine, the active principle of cayenne pepper, shown to the public was exhibited by Mr. Thresh, its discoverer; it was in snow-white crystals.

Capsaicine.

Thresh.

A. W. Gerrard, of London, sent a choice collection of rare and handsome organic proximate principles, among which were salts of pilocarpine in crystals, as nitrate, phosphate, and hydrochlorate; crystalline chrysophanic acid from goa powder; monobrom camphor in crystals two and a half inches in length; and three varieties of aloin, named, according to the place of origin of the drug, *socaloin*, *barbaloin*, and *nataloin*.

A. W. Gerrard.

Organic salts.

Aloin.

Southall & Barclay, of Birmingham, had a collection of extracts made from assayed drugs, and pure chemicals for analytical purposes. They showed an "A" cod-liver oil made in Norway, and alongside of it were arranged a series of small bottles containing proximate principles said to have been extracted from the oil, such as stearic, cetylic, and oleic acids, volatile fat acids, glycerine, biliary matter, and gaduine.

Southall & Barclay.

Cod-liver oil and extracts.

T. & H. Smith, of Edinburgh, had a brilliant exhibit of the preparations of opium, many of which they have discovered, isolated, and described. Among the magnificent specimens were some bodies which are quite new; for example, gnoscopine ($C_{34}H_{36}N_2O_{11}$) and meconoiosine ($C_8H_{10}O_2$); hydrochlorate of apomorphine; one crystallization of codeine, weighing about ten pounds; narceine; meconine; a crystalline mass of hydrochlorate of thebaine of perhaps twenty pounds in weight; thebolactic acid; cryptopine;* nitrate of furfurine; Fowne's artificial alkaloid; large and fine specimens of caffeine, etc. Their collection also contained specimens of opium from almost every source of the drug.

T. and H. Smith.

Opium preparations.

Macfarlan & Co., of Edinburgh, had a very extensive display—about ninety specimens—which was of special interest on account of the number of substitution products of the opium alkaloids it contained. Besides the salts of morphine, codeine, narceine, and the other well-known bases, they exhibited oxynarcotine, hydrocotarnine, apomorphia, salts of trimorphia and tetramorphia, dicodeia, tricodeia, and tetracodeia. They also had acetyl, butyryl, and benzoyl substitution products of morphia and codeia, in which the acid radical takes the place of the hydrogen in the base,

Macfarlan & Co.

Substitution products of opium alkaloids.

* Over a pound of this was on exhibition, although it occurs in opium only to the extent of $\frac{1}{100}$ of one per cent.

GREAT BRITAIN.

Pharmaceutists.

Macfarlan & Co.

Substitution products of opium alkaloids.

Chloroform.

e. g., $C_{17}H_{13}(C_2H_3O)NO_3$, etc. Narcotine, with its derivative opianic acid, was among the specimens, as well as dimethyl, nor-narcotine, etc. Narcotine is an extremely interesting body on account of its many derivations. Opianic acid, which is derived from it by oxidation, may be, by means of an excess of potash, split up into meconine and hemipinic acid, and vanilline has been made from it. It has been found that narcotine, by a series of complex changes, gives rise to anthracine and to alizarine. This house also exhibited a pure chloroform, for the manufacture of which they are quite celebrated.

The exhibits of these two Edinburgh houses were perhaps as full of interest to the pharmaceutist as any in the Exposition.

Morson & Son. Creosote, etc.

Morson & Son, of London, exhibited creosote and preparations from it, pilocarpine and its salts, gelseminic acid (esculine), chrysophanic acid, etc.

Bowdler & Bickerdike. Carbolic acid and derivatives.

Bowdler & Bickerdike, of Church, presented very fine specimens of carbolic acid and derivatives. One of their specimens was about twenty-five pounds of absolute phenol in a granular state and free from color. The granular form of this substance is a guarantee of its purity, since phenol containing the minutest amount of cresol is so deliquescent that it cannot be reduced to a granular condition.

Lowe & Co.

Lowe & Co., of Manchester, also showed fine specimens of carbolic acid and its derivations, together with naphthaline and its tetrachloride, etc.

Savory & Moore. Extracts. Gelatine preparations.

Savory & Moore, of London, exhibited as novelties fluid extracts and tinctures of jaborandi, boldo, guavana, coca, and coto. They also showed an extensive series of gelatine preparations for ophthalmic and hypodermic uses, the newer ones being disks of colchicia, pilocarpine, curarine, and duboisia.

Allen & Hanburys. Jujubes.

Allen & Hanburys, of London, showed handsome jujubes made by Hawker's process.

Richardson & Co. Pearl-coated pills.

Pearl-coated pills were exhibited in an almost endless variety by Richardson & Co., of Leicester, the largest makers of pills in the world. They had on their shelves at the Exposition upwards of six hundred varieties of thin-coated pills, thirty varieties of phosphorus pills being among them.

Kirby & Co. Pills and lozenges.

Kirby & Co., of Hatton Garden, London, also exhibited coated pills, and a new form of medicated lozenge called *glycecolls*, each containing a definite amount of its particular medicine. These glycecolls have for their base probably a mixture of gelatine and glycerine.

GREAT BRITAIN.

Pharmaceutists.

Forster & Gregory. Valerianic acid, etc.

J. B. Readman. Citric acid, etc.

Forster & Gregory, of London, contributed valerianic acid and a number of its salts, a series of hypophosphites, large specimens of bi-nitro-benzene, etc.

J. B. Readman, of Glasgow, showed citric acid in all stages of its manufacture, beginning with the crude juice and ending with the finished product. Native phosphate of alumina is likewise put through the various steps of the manufacture of phosphate of soda from it.

Southall & Barclay. Liebig's Extract of Beef.

A number of specialties or proprietary preparations were exhibited in the British section. After Liebig's Extract of Beef there was the preparation of Southall & Barclay, who claim that their soluble meat contains all the fibrine, gelatine, and albumen of lean beef as well as the mineral matters natural to the meat, and that the whole is partially digested.

Pepsina porci. Peptodyne. Pancreatic emulsion.

Pepsina porci of Morson & Son, and *peptodyne* and *pancreatic emulsion* of Savory & Moore, were on exhibition. From Melbourne, Mr. Bosisto sent a number of his preparations of eucalyptus; and Dr. Day, of Geelong, exhibited a "disinfectant," consisting of rectified oil of turpentine 1 part, benzine 7 parts, and oil of verbena 5 drops to the pint—the size or amount of the "part" not being designated.

Day's disinfectant.

Spirit of eggs.

Messrs. Wyndham displayed a "spirit of eggs," which is said to contain the whole of the egg, shell and all, in a spirituous mixture.

There were several well-known London perfumers and soap makers who had handsome displays of their products, but nothing novel was noticed among them.

BRITISH COLONIES.

BRITISH COLONIES.

Jamaica.

From Jamaica there were numerous specimens of rum, sugar, ginger, dye-woods, etc. Among medicinal plants and materials used in the pharmacist's art were noticed *Eucalyptus globulus*, *Acacia catechu*, *Hæmatoxylon campechianum*, and extracts from them; cocoa-nut oil, oil of *Anacardium occidentale*, oil of *Moringa pterygosperma*, cold-pressed castor oil; essential oils of pimento, of nard, of Seville orange, of lemon, of Barbadoes juniper, and of *Eucalyptus glob.;* and yellow and bleached beeswax.

British Guiana.

Balata gum.

British Guiana contributed honey and Guiana pepper, cocoa-nut oil, balsam copaiba, castor oil, seeds of *Ricinus communis*, bay-rum, wourali poison, fish glue, and balata gum. This substance resembles gutta-percha in many respects, and most of it is shipped from Guiana and sold for that article. It is tasteless, emits an agreeable odor on being

BRITISH COLONIES.

warmed, may be cut like gutta-percha, but is more elastic, tough, and leathery, and remarkably flexible. This gum is inferior in its qualities to india-rubber, but it possesses properties which make it superior to gutta-percha. It is completely soluble in benzole and bisulphide of carbon, and in oil of turpentine by the aid of heat, is a powerful dielectric, and well adapted as insulator for telegraphic and other purposes. This body possesses properties giving it rank between caoutchouc and gutta-percha, and for many purposes will doubtless be found superior to either of them. It is said to be derived from the "bully-tree," which grows on the banks of the Orinoco, and is prepared in a manner similar to that employed in the collection and cure of india-rubber. British Guiana also sent several specimens of arrow-root and many of rum.

British Guiana.

Balata gum.

Cape Colony. Cape Colony sent buchu leaves and aloes. From Cape Town a number of specimens of wines and spirits were sent.

Ceylon. From Ceylon the exportation of cocoa-nut oil amounted to the value of $722,705, of cinnamon bark 1,500,000 lbs., of areca or betel-nut 5,075 tons, and of plumbago to the value of $650,000. Specimens of oils of citronella, of *dihudu*, of *kekuna*, of cocoa-nuts, of *Ricinus c.*, and a number of others from indigenous plants, labeled in the native tongue, were on exhibition. Many fine exhibits of cinnamon were especially worthy of note.

Oils and nuts.

Straits Settlements. From the Straits Settlements (Singapore, Penang, Malacca, and Wellesley) the principal articles of export are pepper, nutmegs, mace, sago, tapioca, gutta-percha, india-rubber, gambier, and essential oils. There were 76 specimens of medicinal herbs exhibited, all carefully labeled with their name and uses in Malayan. Very fine essences of cloves, nutmegs, cinnamon, and patchouly were on exhibition in this section.

Spices, gums, sago, oils, &c.

Essences.

Mauritius. From Mauritius vanilla beans were exhibited of a very fine quality, as well as tapioca, arrowroot, and nutmegs.

Vanilla, manioc.

Seychelles. Seychelles sent cocoa-nut oil, ylang-ylang, cinnamon, pepper, lemon juice, and rum.

New South Wales. New South Wales sent effervescent mineral waters, glue, arrowroot, vinegar, and a number of specimens of wines and ciders.

Victoria. Victoria contributed mineral waters, preparations from eucalyptus, arrowroot, and a great number of wines, some ales, and whisky.

Queensland. In the Queensland collection were found a number of spe-

BRITISH COLONIES.

cies of eucalyptus with medicinal preparations made from them. *Bunya-bunya* gum, a resin from a conifer, and grass-tree gum or *gum accariodes*, derived from *Xanthorrhœa arborea*, which is very fragrant, contains cinnamic acid, and is used for fumigations and for making sealing wax. Senna, gelsemium, quassia, *Ricinus c.*, tapioca, *Croton t.*, oil of orange, lime juice, annatto, and arrowroot were also to be seen in this section. The authorities of the Botanical Gardens of Queensland sent an oil of lemon prepared from the *Eucalyptus citriodora*, and essence of verbena from the scented iron bark. *Pituri*, the drug said to possess such wonderful courage-compelling properties, was exhibited here in small quantities. It is supposed to be derived from the plant *Duboisia hopwoodii*, and, according to A. W. Gerrard, who examined a specimen of the dried leaf by Stas's method, it contains an alkaloid for which the name *pituria* is suggested. It is soluble in water, alcohol, ether, and chloroform, and is stated to give a fine fluorescence to light reflected from its edges or refracted through it when in the solid state; it has a bitter taste, and produces a numbing sensation similar to, but less persistent than, that produced by aconite. Dr. Bancroft, of Queensland, among other things about this singular and interesting plant says: "The plant is used by the natives as a stimulating narcotic, and its use is confined to the men of the tribe Mallutha, all the males of which are circumcised. The old men, before any serious undertaking, chew the leaves, and are then in a sufficiently courageous state of mind to fight or to undertake any serious business. One old man refused to have anything to say or do until he had chewed the *pituri*, after which he rose and harangued in grand style, ordering the explorers to leave the place." In large doses it infuriates the user, and in excessive quantities produces paralysis and death.

Queensland.

Gums, drugs, manioc, etc.

Oils and essences.

Pituri, its origin, nature, and properties.

In the South Australia section a great many exhibits of the varieties of the eucalyptus tree were to be seen. Sandal-wood and mimosa bark for tanning were also found in this collection, as well as olive oil and many wines of good quality.

South Australia.

Oil and tanning extracts.

West Australia sent a great number of specimens of eucalyptus, including almost every variety growing in the land. This tree, besides, is of great value as a timber tree, has lately become quite famous in its hygienic and medical relations, and, if a moiety of what is said about its qualities is true, it deserves the serious and instant attention of the whole world. Professor Bentley, of the Pharmaceutical

West Australia.

Eucalyptus.

BRITISH COLONIES.

Society of Great Britain, says in regard to the medical, pharmaceutical, and hygienic uses and powers of this plant:

West Australia.

Bentley on the Eucalyptus globulus.

"The first and most important influence which the *Eucalyptus globulus* is now commonly said to exert, and that which has brought it into prominent notice, is its power of improving miasmatic climates by destroying the paludal miasm which causes fever in such districts; from which circumstance it has been called the 'fever-destroying tree.' Its influence in this respect was first noticed in its native country, Australia, and evidence to the same effect has now been obtained from all parts of the world where it has been introduced, and which are favorable to its growth. Thus, in Algeria, where it has been tried on a large scale, and in Spain, districts previously noted for their pestilential air, and consequent prevalence of fever, have now become quite free from disease. At the Cape also, in a very few years, its cultivation has completely changed the climatic condition of the unhealthy parts of that colony; thus, in the neighborhood of Constantia especially, it has been stated that a noted fever spot, which was covered with marsh water both in winter and summer, has in five years been dried up by the planting of 14,000 of these trees, and the inhabitants now enjoy excellent health. In Cuba again, marsh diseases are fast disappearing from the unhealthy districts where this tree has been introduced. An interesting statement to the same effect has recently also been reported from Italy, where the planting of some eucalyptus trees, which in six years had grown to a height of over thirty feet, had rendered healthy a part of the Campagna which had hitherto been regarded as the most fever-stricken part of that unhealthy district. The tree has now been planted to a large extent in Italy, and hopes are entertained that in a few years malaria will be as effectively expelled from that country as ague has been from Lincolnshire [in England]. The testimony in favor of its anti-malarial influence is so strong that, allowing for exaggeration in some cases, it can scarcely be doubted that this tree does produce a most beneficial effect by destroying the fever-producing miasm of marshy districts; and that it should consequently be introduced into all countries and districts where the climatic influences are favorable for its development, and where such miasmatic emanations are to be found.

The fever-destroying tree.

Experiments in Algeria,

Spain,

Cape of Good Hope,

Cuba,

Italy.

Its mode of action.

Absorption of water.

Odorous emanations.

Investigations of Kingzett.

"The influence of the eucalyptus in this respect is commonly regarded as being serviceable in two ways. First, by the far-spreading roots of this gigantic tree pumping up water as it were, and thus draining the soil; and, secondly, by the odorous emanations from its leaves having a disinfectant and antiseptic influence on the paludal miasm. * * * The very interesting investigations of Kingzett have proved that under the influence of air and moisture both peroxide of hydrogen and camphoric acid are formed from volatile oils, the former a powerful disinfectant and the latter an antiseptic; and hence there can now be no doubt that the healthy influence of eucalyptus trees is, to some extent at least, and probably more than we imagine, due to the volatile emanations from the leaves under the influence of air and moisture, possessing direct disinfectant and antiseptic properties, and thus destroying the injurious effects of paludal miasms.

Antiseptic properties of *eucalyptol.*

"Another circumstance which has an important bearing upon the antiseptic properties of the leaves of eucalyptus is that the *eucalyptol* of Cloez, the chief constituent of the volatile oil contained in the leaves, has been recently proved to possess great antiseptic properties.

BRITISH COLONIES.

"The greatest influence in the author's opinion is produced by the power the roots possess of absorbing water from the soil. It is stated that a moderate-sized eucalyptus tree absorbs as much as ten times its weight of water from the soil; and hence, allowing for exaggeration, the enormous suction power of large plantations of such trees may in some degree be judged of; so that when thickly planted in marshy places, 'the subsoil is drained in a little while as though by extensive piping.' That the main influence of eucalyptus trees is thus due to the absorptive power of the roots is also borne out by the fact that other plants of rapid growth, when planted in marshy districts, have a sensible effect in diminishing their malarial influence. This is notably the case with the sunflower, which is grown for this purpose to a large extent in the swampy regions of the Punjab and other parts of the world; and the effect has been that districts which were previously remarkable for their insalubrity are now reported to be entirely free from miasmatic fever.

West Australia.

Bentley on the Eucalyptus globulus.

Its effect mainly due to absorptive power.

Effect of the sun-flower.

"The leaves of the eucalyptus upon distillation with water yield large quantities of an essential oil. This oil is stored up in the pellucid glands contained in the leaves, and which may be readily observed when they are held up to the light by the semi-transparent appearance they then exhibit. These oils are now prepared on a large scale, and form an important article of commerce between this country [England] and Australia. They have generally a somewhat camphoraceous smell, but the odor of *Eucalyptus globulus* is by no means agreeable in its concentrated state, while that of *E. citriodora* has a pleasant citron-like odor. Most of the oils as imported have a yellowish color, although others are somewhat blue, but when redistilled they are all nearly colorless.

Eucalyptus oil.

E. citriodora.

"These oils have been employed for various purposes; thus, that of the *Eucalyptus oleosa* as a solvent for resins is much used in the preparation of varnishes; but they are also of value for diluting the more delicate essential oils which are used in perfumery. Mr. Rimmel has especially recommended them for this purpose, and specimens of soaps and other substances thus scented are now exhibited. The oils more especially recommended on this account are those of *Eucalyptus amygdalina*, *E. globulus*, and *E. citriodora*.

E. oleosa.

"A recent application of the oil of *Eucalyptus globulus* is also made by Mr. Rimmel, who has introduced what he has termed an 'Aromatic Ozonizer,' and which he recommends as a pleasant disinfectant. It is in the form of a coarse powder, composed of pine-wood sawdust, through which is diffused the oil of eucalyptus, and also the oils of lavender, rosemary, and thyme. The author finds that it certainly communicates an agreeable freshness and pleasant odor to the air of rooms."

Rimmel's "Aromatic Ozonizer."

In consideration of the beauty of the different species, the proved influence of *Eucalyptus globulus* in destroying the pestilential character of marshy districts, and the numerous important economic and medicinal products which the eucalypti yield, this genus of plants must be regarded as one of the most important to man in the vegetable kingdom.

Value and importance of the tree.

From British India were exhibited a great number of specimens of different kinds of woods which furnish dyeing, tanning, or medicinal substances, and alongside were many

British India.

BRITISH COLONIES.

British India.

well-arranged samples of gums, roots, barks, resins, etc., derived from them. One of the most interesting features in connection with this exhibit was the display of the barks from the several species of cinchona which have been introduced and now extensively cultivated in that empire.

Acclimation of the cinchona tree.

The following brief history of the acclimation of the cinchona tree in India will serve to give a hint to our own countrymen of the comparative ease and rapidity with which this important industry has been introduced into a pestilential country, and perhaps be a means of directing the attention of some of our public-spirited and philanthropic capitalists to a subject of the very greatest importance to the future welfare of our people:

Birdwood on cinchona cultivation in India.

Cinchona cultivation in India. By George Birdwood, M. D., of the British Indian Section of the Exposition Universelle, Paris, 1878.

"The introduction of cinchona cultivation into India was undertaken with the object of insuring a cheap and unfailing supply of the febrifuge for the use of the millions who annually suffer from fever.

"Fever is by far the most prolific cause of death in India, carrying off very many more than all other diseases and accidents put together.

Prevalence and fatality of fever in India.

The total number of deaths from fever in India is upwards of a million and a half annually. At least half these deaths will eventually be prevented by putting some cheap form of the cinchona alkaloids into every druggist's shop in the country, at one rupee per ounce; and thus multitudes will be saved from death or grievous suffering.

Difficulties in the introduction of the cinchona tree.

"The successful introduction of cinchona cultivation into India has been a task of considerable difficulty in all its stages. It was not only necessary to transplant a genus of plants from one side of the world to the other, it was also an essential element of success to convert wild into cultivated plants. This involved a close study of the climate, soil, and general physical aspects of each region where the valuable species grow in their native forests; a comparison of these circumstances with those prevailing in the East Indies; the discovery of the best species, and also of the species best adapted to secure good results in their new home; the study of all the requirements of the plants under cultivation, without any guide, as the cinchona had never before been cultivated; and, finally, the solution of numerous very complicated questions relating to the best and cheapest form in which the febrifuge can be provided for general use.

Markham's initiatory projects.

"The task was difficult and complicated. Mr. Markham undertook it in 1859, and all arrangements connected with the collection of plants and seeds in South America, and their conveyance to India, have been made by him, and carried out under his superintendence. His original plan was to depute collectors to the different regions of the Andes where the various species flourish, to have the collections made simultaneously, and to convey them direct across the Pacific to India in a special steamer. But only a portion of his scheme obtained sanction, and no steamer was provided. He was, however, determined that all the species should be secured eventually, and that the work should be complete, even if it extended over many years. This has been the case. It has taken many years to do what might have been done in

one or two, and the expense has been quadrupled. Yet the whole work is now at last complete.

Birdwood on cinchona cultivation in India.

"In 1859 Mr. Markham was only able to organize three expeditions: one, under his own command, to obtain plants and seeds of the Calisayas and other species from Caravaya, in Southern Peru, yielding the yellow barks of commerce; a second, under Mr. Pritchett, to collect species in the forests of Central Peru, yielding the gray barks of commerce; and a third, under that eminent botanist Richard Spruce, to collect plants and seeds of the *Cinchona succirubra* in the forests of Ecuador, yielding the red bark.

Markham's expeditions to Peru and Ecuador.

Pritchett.

Spruce.

"In 1860 the whole of this work was done, and done thoroughly, so far as the difficult and dangerous part of it in the Andean forests, and the conveyance of the plants to seaports on the coast of the Pacific, were concerned; but the failure to furnish the means of direct conveyance to India led to disasters which were inevitable. The plants had to be conveyed across the Isthmus of Panama, then to England, then across Egypt, and down the Red Sea to India. The first installment from Southern Peru all died on the passage, or after reaching India; but the seeds forwarded in the following year germinated, and thus a stock of *C. calisaya* trees was secured. Subsequently more seeds from Bolivia, collected by Mr. Ledger, were received, and the plants raised from them have proved to be an exceedingly valuable variety, which has received the name of *ledgeriana*. The second installment of plants, consisting of those yielding gray bark, was equally unfortunate, but the precaution had also been taken of obtaining seeds, from which a stock of plants yielding gray barks was established in India. The third installment, coming at a cooler season for passing down the Red Sea, was more fortunate. It consisted of plants of *C. succirubra*, yielding red bark, nearly all of which arrived safely. Thus by 1862 the arrangements made by Mr. Markham as regards the above species were crowned with complete success; but the work of introducing all the best species was still far from finished. It remained to obtain the valuable species from Ecuador, yielding the crown barks, and also the renowned species of Colombia.

Work accomplished in 1860.

Difficulties in collecting and transporting.

Failure of imported trees, and success with seeds.

Ultimate success by 1862 with certain species.

"Accordingly Mr. Markham obtained sanction for the dispatch of a collector to Cuenca and Loxa, in Southern Ecuador, to obtain seeds of the *C. officinalis*, the original species of Linnæus (afterwards called *C. condaminea*), from the bark of which the Countess of Cinchon was cured. For this service he selected Mr. Robert Cross, an experienced gardener, who had already acquired experience under Mr. Spruce, with instructions to obtain a supply of seeds of the best Loxa species yielding crown bark. Mr. Cross reached Ecuador in 1862, made a good collection in spite of extraordinary difficulties, and the seeds arrived safely in India and Ceylon, and germinated freely. Mr. Howard, the well-known quinine manufacturer, also presented a fine plant of *C. officinalis* (var *uritusinga*), from which a large stock has been obtained. Thus the introduction of the crown-bark species was secured.

Expedition of 1862 to Southern Ecuador.

Robert Cross.

Howard.

"Mr. Markham's next care was to obtain and introduce plants of a valuable species called *C. pitayensis*, which grows on the slopes of the central cordillera of Colombia, near Popayan. For this work he again secured the services of Mr. Cross, who set out in 1863 and made a good collection of seeds, but, owing to damage suffered in their transit, they did not germinate. After some delay Mr. Markham obtained sanction for a second attempt, and in 1868 Mr. Cross again set out for Colombia, this time with more fortunate results, for the seeds of *C. pitayensis* col-

Expedition of 1863 to Colombia.

Expedition of 1868.

BRITISH INDIA.

lected by him near Popayan arrived safely, and germinated freely in India.

Birdwood on cinchona cultivation in India.

"Meanwhile the destruction of *C. pitayensis* in its native forests led the collectors to seek for other trees in more distant regions, and a new bark began to appear in the market, of great value, known as the *Calisaya de Santa Fé*. Mr. Markham resolved that this species should also be introduced into India. The service was one of special difficulty and danger, for the trees are only found on the eastern cordillera of Colombia, near the sources of the Cagneta. He again intrusted the work to Mr. Cross in 1877, and again his confidence in that intrepid and most able explorer was justified. In March, 1878, Mr. Cross arrived at Kew with a good supply of plants of the *Calisaya de Santa Fé*, and also of the *C. cordifolia*, yielding the Carthagena barks of commerce.

Expedition by Cross to Colombia, 1877 and 1878.

Varieties now growing in India.

"Thus at length all the valuable species of febrifuge cinchona plants indigenous to South America have been successfully introduced into India. They are as follows:

C. calisaya (yellow barks), Bolivia and Caravaya.
C. nitida, *C. micrantha*, *C. peruviana* (gray barks), Central Peru.
C. succirubra (red barks), Ecuador.
C. officinalis (crown barks), Ecuador.
C. pitayensis (Pitayo bark), *Calisaya de Santa Fé*, *C. cordifolia* (Carthagena barks) — Colombia.

"The first and most hazardous stage of the enterprise was the collection of the plants and seeds in South America, and their conveyance to India. The second and equally difficult stage was the cultivation and the discovery of the species best suited for India, as well as the best method of treatment with a view to producing the largest percentage of febrifuge alkaloids in the barks.

Determination of the varieties best suited for India.

Selection of sites.

"The first step was the selection of the most suitable sites for the plantations, being those having most resemblance to the native habitat of the cinchona. Mr. Markham proceeded to India in 1860 to perform this duty; and chose a site at Neddivattum, on the northern slopes of the Neilgherry Hills, facing Wynaad, for the plants of *C. succirubra*, the *C. calisaya*, and gray barks, and a site at a greater elevation, under the Dodabetta Peak, for the *C. officinalis* plants. He also selected sites for plantations in Coorg and the Pulney Hills, and, on the occasion of a second visit to India in 1866, in Travancore and Wynaad.

Neilgherry Hills and other sites.

Conversion of the tree from the wild state to cultivation.

"The successful conversion of the cinchona from a wild to a cultivated tree is due to the unrivaled skill and ability of the late Mr. McIvor, superintendent of cinchona cultivation in the Madras Presidency. Mr. McIvor propagated the plants with great success, established them in the plantations, discovered the conditions under which they would give the largest yield, and also the method of renewing the bark by the mossing process, which undoubtedly secures an increased percentage of febrifuge alkaloids. The final conclusions are that the *C. succirubra* species is best adapted for use in India, and for furnishing abundant supplies of a cheap febrifuge; while the *C. officinalis* and the Colombian kinds will be the most valuable barks for the London market, and for securing a remunerative return on the outlay. By 1870 the Neilgherry cinchona plantations belonging to the government covered 1,200 acres of ground; while private individuals possessed several thriving and paying plantations on the Neilgherries and in Wy-

Conclusion as to the best varieties for use and for market.

Extent of plantations.

nand, 235,747 plants having been distributed up to 1875. In the same year there were over a million cinchona trees in the government plantations.

Birdwood on cinchona cultivation in India.

"In 1862 a cinchona plantation was established in British Sikkim, under the superintendence of Dr. Anderson, plants of *C. succirubra* having been obtained from the Neilgherry Hills. Other kinds are not likely to flourish in the Sikkim climate, but the *C. succirubra* is well established in the Rungbee plantation. By the year 1875 there were upwards of two million plants of *C. succirubra* at Rungbee, and the propagation can be carried on with ease to any extent.

Plantation in Sikkim.

"Thus the second stage of the enterprise, namely the cultivation, was crowned with complete success.

"The third and most important measure is the supply of a cheap febrifuge to the people. As soon as it was established that the *C. succirubra* would be the best species for India a very critical point arose. That species yields a very large percentage of total febrifuge alkaloids, but only a small quantity of quinine. Mr. Markham saw that it was of vital consequence to discover the medicinal value of the other alkaloids, namely, cinchonidine, quinidine, and cinchonine, and to ascertain whether they, equally with quinine, possessed the precious febrifuge qualities. He accordingly obtained the appointment of medical commissions in 1866, for each of the three presidencies, to investigate and report upon this question. The result was that cinchonidine (the principal alkaloid in *C. succirubra*) and quinidine were found to be quite equal to quinine, and cinchonine inferior, though still efficacious in larger doses. This was a great point, for it made a cheap febrifuge medicine possible. The extraction of pure quinine is an expensive process, but the production of a medicine containing the total alkaloids in the bark is easy and simple.

Production of cheap febrifuge.

Tests of medicinal value of the various alkaloids.

Result.

"This important fact having been established, Mr. Markham next urged the adoption of a measure calculated to secure the final object of the introduction of cinchona cultivation into India, namely, the preparation of a febrifuge medicine at the government plantations which should contain all the alkaloids, and should be salable at a cheap rate. With this object Mr. Broughton was appointed as quinologist on the Neilgherry Hills in 1866, and in 1873 Mr. Wood received a similar appointment for the Sikkim plantations. Mr. Broughton adopted a method for the manufacture of his medicine which entailed the use of alcohol, and was, therefore, too expensive. Up to 1873 he had made about 600 pounds of an amorphous cinchona alkaloid, but the essential requisite of cheapness was not secured. His method was consequently abandoned. Mr. Wood began his actual manufacturing operations in 1875. His method is the same as that recommended by the learned quinologist of The Hague, Dr. J. E. De Vrij, who calls the resulting product *quinetum*. The powdered bark is first exhausted with cold acidulated water, and the resulting liquor is precipitated by a caustic alkali. Scarcely any fuel is required, and no expensive machinery, merely some wooden tubs and calico filters. There can soon be yielded by this process about 140,000 ounces of an efficient cinchona alkaloid every year, at a cost of less than 1 rupee per ounce. Quinine, in England, is from eight to nine shillings an ounce, and in India the price is much higher.

Cheap process of preparation required.

Broughton.

Wood's adoption of the De Vrij process.

"Thus the great object of this difficult undertaking is on the eve of being secured, and an inestimable blessing will be conferred upon India, while at the same time the barks rich in quinine will be sold in the London market, and will repay all the outlay with interest. The

Proximate entire success.

BRITISH INDIA.

Benefits of cinchona cultivation.

sum of 40,000*l.* was realized by these sales in 1877 alone. While, on the one hand, cinchona cultivation will be a most remunerative public work, on the other it will rob the malarious fevers of India of three-fourths of their victims, and will to that extent diminish the amount of human misery and suffering."

HOLLAND.

HOLLAND.

From this country very few exhibits of interest to the pharmaceutist were shown.

Mouton & Sons.

Mouton & Sons, The Hague, exhibited a large collection of pharmaceutical preparations and general chemical products of fine appearance.

Quinetum. Dr. De Vrij.

Quinetum of Dr. De Vrij was exhibited by this firm.

Dr. Sanders.

Dr. Sanders, of Amsterdam, exhibited peptones of meat, fibrin, milk, peptonized vegetable albuminoid substances,

Peptones and pancreatine.

peptonized bread, peptone chocolate, peptone capsules, solutions of pancreatine, and pancreatine in substance. The following account of peptones was given in connection with this exhibit and published in the Official Catalogue of the Dutch section: The establishment of Dr. Sanders was established in 1875, and the business has grown to such an extent that it requires a steam-engine of six-horse power and a number of operatives to manufacture a sufficiency of products to supply the demand. The amount of peptone, in one

Production.

form or another, turned out by the factory annually is 25,000 kilos. Peptone, known in physiology and chemistry as the product of the digestion of the albuminoid bodies in the intestines, by means of the gastric and pancreatic juices, is

Character of peptone.

distinguished from albuminoid bodies (1) by the facility with which it passes through the dialyzing membranes and the walls of the intestines and its rapid absorption by the blood; (2) by certain chemical properties, among which may be noted its great solubility in water and its non-coagulability by heat, by acids, by alkalies or their salts, or by sulphate

Tests for recognition.

of iron. Peptone is easily recognized by its hygroscopic property, by the violet-red color produced by the addition of sulphate of copper to its solution, rendered alkaline by caustic fixed alkali, and by the yellow coloration produced by the addition of nitric acid. Albuminoid bodies, after their conversion into peptone and absorption into the blood, are there reconstructed into albuminoids. Thus, peptone introduced into the stomach or into the bowels by injection

Action and value of peptone.

requires no digestion, and the whole nutritive effect is produced without drawing on the flagging energies of the system and without delay; and as peptone represents the principal elements of nourishment—albuminoid substances—it recommends itself whenever there is need of rapid and vigor-

ous reparation, or in cases where digestion is defective or inadequate, as in typhoid fevers, dysentery, or other intestinal diseases. Peptone is prepared by digesting meat by exposing it in contact with the pancreas of bullocks at a proper and well-regulated temperature. At the same time a peptone of bread is made, so that by a combination of the meat peptone with that of bread a complete food is made. The strength of the peptonic solution is such that one part of it represents three parts of the digestible elements of meat. It is sent into market in hermetically sealed tin-boxes, of 250 grams each, at a retail price of 4 fr. per box. The bread peptone is a thickish, nearly dry mass, and is sold for 3 fr. per box.

Peptones. Dr. De Vrij.

Mode of preparation.

A completely digested food.

Meat and bread peptones.

DUTCH COLONIES.

The exhibition in this section was very full and varied, and possessed much interest to the student of natural history. The most important displays—to the pharmaceutist—were those of the cinchona barks and of vanilla.

De Groat & Co., of Amsterdam, showed the finest collection of vanillas in the Exposition, displaying beans of *Vanilla aromatica* from Mexico and Mauritius, of *V. plantifolia* from Bourbon and Java, as well as the spirally-marked vanilla from Guadeloupe. They had pure vanilline extracted from the bean and artificial vanilline in their collection. The chief varieties of cinchona bark—this bark now being one of the most important products of Java—were exhibited, such as *Cinchona caloptera*, *C. calisaya*, *C. hasskarliana*, *C. lancifolia*, *C. micrantha*, *C. officinalis*, *C. pahudiana*, and *C. succirubra*. The first cinchona plantations were laid out in 1854, and in 1873 the number of trees was estimated at no less than 2,000,000, from which an annual product of 100,000 kilos of bark is obtained.

De Groat & Co.

Vanillas.

Vanilline.

Cinchona.

A number of edible birds' nests were exhibited, and oil of green turtle, coming from Dutch Guiana, was noticed among the specimens.

Edible birds' nests.

ITALY.

The manufacture of pharmaceutical preparations has made comparatively rapid advances within the past few years in Italy. While 10,000 kilos of sulphate of quinine are required in the country itself, the annual production is nearly double that amount. In Sicily large quantities of citrate of quinine are prepared from the sulphate by means of citrate of barium, and in Pavia and Milan large amounts of the valerianate are manufactured. Lemon juice forms a prod-

Sulphate of quinine and derivatives.

ITALY.

uct of considerable importance—annual value of export $560,000. As it is almost exclusively used for the preparation of citric acids in other countries, efforts are being made to extend this branch of manufacture in the country itself.

Lemon juice.

Manna.

The collection of manna forms an industry of some importance in Sicily and Calabria. The exportation of flake manna is 39,500 kilos (worth $39,500) and of manna in sorts 197,400 kilos (worth $79,000).

Essential oils.

The manufacture of essential oils, oil of bergamot, etc., is likewise extensively pursued in Southern Italy.

Castor-oil.

In Northern Italy no less than 16 establishments are engaged in the manufacture of castor-oil, enormous quantities of which are exported to other European countries and America. The raw material comes either from the province of Venetia or Asia Minor and India.

Licorice.

The exportation of extract of licorice in 1877 was 12,204 quintals more than the imports of that commodity during the same period.

Olive-oil.

Olive-oil was exported from the kingdom in 1877 to the large amount of 602,301 quintals.

Prof. de Luca.

Professor de Luca, Naples, sent an interesting exhibition of mannite obtained from the leaves, fruit, and flowers of the olive; cream of tartar prepared from the leaves, blossoms, and fruit of the myrtle.

Dufour Bros.

Dufour Brothers, Genoa, exhibited mannite and pure salts of quinine.

B. Valeri.

B. Valeri, Vicenza; established in 1832, and employs 50 operatives and 14 hydraulic presses. The annual production is 800,000 kilos of castor-oil.

L. B. Sarnico.

Luigi Biseo Sarnico, Bergamo, exhibited sublimed naphthaline in a compressed and in a fused state.

Alessi & Bonaventura.

Alessi & Bonaventura, Messina, contributed fine essential oils of bergamot, lemon, and bitter orange, extracted by hand, and concentrated lemon juice for exportation to makers of citric acid.

Antonio Tommasi.

Antonio Tommasi, Perugia, showed pure asparagine.

M. Donadeo.

M. Donadeo, Carpanzano, sent borate of caffeine.

Lorenzo Incardona.

Lorenzo Incardona, Caltanissetta, exhibited a collection of pharmaceutical preparations, among which were the citrate and the bisulphate of quinine, ferro-cyanide of quinine, and granular effervescent citrate of magnesia.

Fabr. Lombardi di Pro. Chimici.

Fabbrica Lombarda di Prodotti Chimici, Milan, was established in 1873.

Dr. C. Forst.

This establishment, founded by A. Boehringer and under the chemical direction of Dr. C. Forst, although young, ranks among the most important manufactories of

Sulphate of quinine.

quinine of the day. The annual production is 18,000 kilos of sulphate of quinine, extracted from over 700,000 kilos of bark—about a quarter of the total amount prepared in Eu-

ITALY.

rope. The exhibit of the various salts, iodated and bromated derivatives, etc., of the cinchona alkaloids was very fine, and included 40 derivatives of quinine, 22 of cinchonidine, 17 of quinidine, 15 of cinchonine, etc. At present large quantities of the valerianate of quinine are manufactured, use being made not only of the natural valerianic acid, but also of the acid obtained synthetically from amylic alcohol. This firm, in addition to the alkaloids and their salts, which form the principal product of the establishment, exhibited a series of compounds which are of interest at present more from a scientific point of view than for any economic or medical use they have; for example, the iodides of quarternary ethyl and methyl bases. Quinicine and cinchonicine are presented as examples of transformations which the original bases undergo when exposed to the action of heat under certain conditions. Dihydroxyl-quinine—a product constantly encountered in the urine of persons suffering from quinism—is shown, along with a magnificent specimen of bromated quinine—a compound not before exposed in public, bibromated cinchonine, and bibromated cinchonidine and cinchotenine—all being bodies of quite recent discovery. Quinic and quinoric acids and some of their salts figured in the collection. To the ordinary and well-known salts of quinine the following were added: The benzoate, bromohydrate, sulpho-cyanate, acid citrate, nitrate, and phloretate. By the side of anethol-quinine, known generally under the name of anisate, the true anisate is placed, and in juxtaposition with the hydrochlorate and of the sulphate of phenol-quinine, known under the names of chloro-phenate and sulpho-phenate, the true phenol-sulphonate is put. In the immediate neighborhood of a specimen of very fine crystals of valerianate of quinine, prepared with valerianic acid from valerian roots, were found several preparations of special scientific interest, representing salts of quinine with several varieties of valerianic acid, prepared by synthesis. They were—

Fabr. Lombarda di Prod. Chimici.

Sulphate of quinine and derivatives.

Bromated quinine.

New salts of quinine.

(1) Valerianate of quinine, containing the normal acid (pentylic acid).

(2) Valerianate of quinine, containing isobutyl-formic acid.

(3) Valerianate of quinine, containing trimethyl-acetic acid.

(4) Valerianate of quinine, containing methyl-ethyl-acetic acid

HUNGARY.

HUNGARY.

This country is very rich in natural products, and depends mainly on them for her subsistence. The chemical and pharmaceutical arts are far from the state of development to be seen in other parts of the Austrian Empire. The principal exports of commodities of interest to the druggist or chemist are tan-bark, 2,000,000 metric quintals per annum; beeswax is produced of the value of 770,000 fr. per annum, as well as considerable amount of tartar, tartaric acid, and glycerine. Hungarian indigo was exhibited by three or four firms.

Tan-bark, beeswax, acids.

Among the few who exhibited pharmaceutical preparations may be mentioned the establishment of Mátyás Rozsnyay, of Arad, who exhibited a large specimen of nearly colorless coniine, and confections of sugar and chocolate containing such medicaments as tannate of quinine, santonine, etc.

Mátyás Rozsnyay.

Other Hungarian exhibitors.

Lipót Flamm, of Worsetz, exhibited liquid fish-glue.

Stabilimento Prodotti Chimici, Fiume, had a display of chemical products.

M. Lengauer & Son showed a good specimen of crystallized tartar and tinctorial substances.

Gyula Beszédes, Duna-Vecse, contributed a collection of chemical and parmaceutical products.

JAPAN.

JAPAN.

It has become fashionable to call the Japanese the Parisians of the East, on account of their good breeding, politeness, neatness, and cleanliness, but more especially because they have equaled and even surpassed their antipodes in some of the finer mechanical and metallurgical arts. It was impossible to visit the Japanese section without experiencing a feeling of wonder, mingled with admiration, at the evidences of a superlative knowledge and skill displayed in most of the exhibits made by this extraordinary people. But there are points of difference between them and the French, and this difference is to be noticed in the department of the natural sciences and the arts growing out of them. Chemistry and pharmacy and collateral arts were scarcely represented at all, and what few specimens there were on exhibition were mainly natural products from the vegetable and mineral kingdoms; very few manufactured articles were to be seen. Their vegetable products were displayed along with dried specimens of the plants from which they were derived, or a very perfect pictorial representation

Their excellence in certain mechanical and metallurgical arts.

Not in chemistry and pharmacy

Exhibits principally natural products.

JAPAN.

of the growing plant was suspended along with the object. The botanical, as well as the Japanese, name was appended, and also a short account of the properties and use of the drug. Perhaps the most important product exhibited was the *thao* or Japanese isinglass, already mentioned under the head of French Cochin-China. This costly and valuable substance may, and likely will, come into extensive use in the western world (many manufacturers already have been using it in a quiet way for several years); and since it is produced from several species of algæ growing around the Asiatic coasts, there would seem to be no reason why it might not be manufactured on our coasts. The specimens of marine plants exhibited as sources of the variety of gelose referred to were *Euceuma spinosa*, *Glœopeltis intricata*, *Gymnongrus pinnulatus* and *G. flabelliformis*, *Kalymenia dentata*, and *Halochloa macrantha*.

Thao

Made from algæ.

K. Tamagawa, of Miye, exhibited crude and prepared opium.

Exhibitors.

Mitsuï-Boussan-Kuaïsha, of Tokio, sent crude and prepared bees-wax and vegetable coloring matter.

R. Mori, department of Kochi, Y. Katsoukoura and B. Amaka all exhibited indigo in fragments and in powder.

Kô-bou-Kôzan-Kiokou, of the Bureau of Mines of the Ministery of Public Works, sent a handsome collection of minerals, such as auriferous, argentiferous, and cupriferous ores, pyrites of iron, magnetite, hematite, galena, graphite, tin-stone, pyrolusite, mercury, jasper, cobalt, rock-crystal, agates, quartz, garnets, calc-spar, kaolin, amber, native sulphur, lignites, etc.

Bureau of Mines.

Mineral collection.

MONACO.

MONACO.

This little principality contributed, through its Société Industrielle et Artistique, several new products serving as *matières premières* for the perfumer's art, such asodoriferous principles of orris, musk, cassia, tonqua, and orange flowers, in a concrete state. They were prepared by a special process not described (supposed to be that of Millon), which yields products of great concentration and of exquisite perfume. The advantages claimed for the *principe odorant de l'iris* is that it retains the delicious perfume of the root free from acrid odorous matter which accompanies it in the extract prepared by the ordinary process; besides, it enables the perfumer to make a colorless tincture instead of the usual colored one, and finally it gives 100 times its volume of extract. The odorous principle of musk, likewise made by a new process, preserves all the desirable qualities

Société Industrielle et Artistique.

Perfumery.

MONACO.

Perfumery.

of the perfume to the exclusion of the colored and nauseous principles of the drug. Coumarine or odorous principle of the tonqua bean, made by the secret processes of the society, is very concentrated, and on dilution gives a colorless tincture. These remarks apply to the concrete essence of cassia and orange flowers. As medicaments the society exhibited various pharmaceutical preparations of *Eucalyptus globulus*, a sirup of carouba, and a saccharale of orange flowers. Prices were given of several of these preparations, as follows:

Price of essences.

Principe odorant de l'iris	300 fr. the kilo.
Principe odorant du musc	96,000 fr. the kilo.
Coumarine	1,000 fr. the kilo.
Essence concrete de flours d'oranger	1,000 fr. the kilo.
Essence concrete de casse	1,450 fr. the kilo.
Essence de rose de Provence	1,100 fr. the kilo.

NORWAY.

NORWAY.

The principal articles exhibited from this country of interest to chemists, druggists, parmaceutists, and the medical profession were cod-liver oils of various qualities, ammoniacal salts from gas works, ink and blacking, oxalic acid made from wood fiber, and sulphuric and nitric acids.

Cod-liver oil, ammoniacal salts, ink, blacking, and acids.

Exhibitors of cod-fish oil.

C. Jordan, of Throndhjem; P. Möller, of Christiania; C. Johnssen, of Christiansund; Isdahl & Co., of Bergen; J. H. Henricksen, of Tromsö; T. U. Borthen, of Trondhjem; M. H. Astrup, of Christiansund; C. K. Gran, of Bergen, and ten others, sent specimens of the oil of the livers of various species of the codfish.

The following account of the cod-fishery of Norway, and the manufacture of cod-liver oil, was kindly sent to me in a private letter by L. Monrad Krohn, of Bergen, a member of the International Jury of Recompenses for Class 47 of the Paris Universal Exposition of 1878:

L. Monrad Krohn on cod-fishery and cod-liver oil.

Fishing the staple branch of industry in Norway.

"From the earliest times it is well known that fishing has been the staple branch of industry in Norway, notwithstanding that the Norwegian coast is not richer in fish than those of England, France, and the Mediterranean. It has had and still continues to have its periodical shoals from the Atlantic of different varieties of fish—*e. g.*, mackerel, herrings, cod, etc.—which visit the coast and deposit their spawn. The daily production is not more than is consumed by the inhabitants of the town and thinly-spread populations along the coast.

Periodical fisheries.

"The periodical fisheries are of an extensive nature, covering an area of not less than 200 geographical miles along the coast, commencing south, at Bergen, and proceeding north as far as the Lapland sea.

"There are three fisheries of special interest and great importance:

	Latitude.
(1) At Sondmore and Romsdalen	62°–64°
(2) At Vestfjord and Lofoden	67°–69°
(3) At Finmarken	70°–71°

"The fishing in the south commences at Bergen, Sondmore, and Romsdalen in the months of January and February, and afterwards, and not unfrequently at the same time, in Vestfjord and Lofoden Isles, where it continues to the end of March, at which time it commences at Finmarken. The annual production amounts to nearly 50 millions, towards which the first-mentioned fishery contributes 6 to 10 millions, and the second 24 millions, while the third contributes 10 to 14 millions.

L. Monrad Krohn on Norway fisheries.

"As the fishing season commences in the depth of winter, when the sea is extremely rough, it is easily to be understood that in open boats it is a very hazardous occupation, and gives but an indefinite supply when dependence must be placed on the state of the weather.

Seasons and production.

"In the cod-fishing alone are employed upwards of 20,000 souls, who do not live in the immediate neighborhood of the fish, but far off on the coast, and put off in their boats in the severest weather. But now, in the present century, when steam navigation has become so important in this country, extending from its capital along the coast to the extreme north, the fishermen prefer to follow the shoals in steamers from point to point.

Persons employed.

Steamers employed.

"At the chief points are the fish-curing establishments, where the cod is carefully salted and dried, after the interiors have been removed therefrom, and the heads, which are made into manure; the ova being salted and barreled for the French sardine-fishing, and the liver being secured by the oil manufacturers.

Curing.

"It is probable that cod-liver oil has been made at all times for technical use, and there were known two kinds—the pale and the brown oil. About the year 1830 was introduced the first oil for medicinal use, and from that time better qualities have been demanded in Bergen, the chief market for all kinds of fish produce.

Introduction of cod-liver oil into pharmacy.

"The exportation of oil for medicinal use has increased from year to year. About the year 1846 it became more extensively used, Dr. De Jong having brought it under the notice of the medical faculty, and since then his name has become familiar throughout Europe. In about the year 1860 Mr. P. Möller, of Christiania, introduced the method of extracting the oil by means of steam, which in all respects is superior to the methods previously in use, inasmuch as the oil is extracted at a definite temperature, and the more solid portions, which consist chiefly of stearine, remain in the deposit. Since that time the oil has been more carefully prepared, inasmuch as the consumers insisted on a better product. In order to produce one barrel of oil (25 gals. or 120 liters) in the common way, double the quantity of livers is required; 1,000 livers yield one barrel of oil. But this chiefly depends on the quality of the livers, which is variable, as they do not always consist of pure fat, *i. e.*, before spawning. The finest quality of oil now in the market is that prepared after Möller's system, which consists of subjecting the livers to the direct action of steam in tinned pans, or by slowly treating the livers in pans inclosed in steam jackets—the latter to be preferred.

Increased exportation of the oil.

Dr. De Jong.

P. Möller's steam process for extracting.

Livers to the barrel.

Möller's process.

"The conditions necessary for a good oil are these: (1st) Livers from freshly-caught fish, and in no case should they be kept over twelve hours in the net; (2d) in removing the liver great care must be taken not to injure the gall-bladder, otherwise the afterproduct will be of a bitter and disagreeable taste. After the livers have been washed with water and dried between folds of cloth, before placing them in the pan they are subjected to the action of steam; the oil separates easily from the liver and rises to the surface of the water or condensed steam, while the solid matter falls to the bottom; then the oil is skimmed and passed

Conditions for a good oil.

NORWAY.

L. Monrad Krohn on Norway fisheries and cod-liver oil.

through canvas bags or filters and put into barrels lined with tin-plate, and left in these barrels in a cool room, in order that the stearine may deposit.

Mode of preparing.

"The fresher the liver and more cleanly the apparatus the paler and better in quality will be the oil as regards color and aroma. The barrels are allowed to remain in the rooms from one to two months at a medium temperature; the oil seems to undergo a peculiar kind of fermentation, becoming bright and depositing its stearine, more or less, the amount depending chiefly on the pressure used in passing through the filter—so much pressure being sometimes used that the oil contains some 25 per cent. of stearine. This method is much to be preferred to the older, which consists in filtering through paper or canvas bags, thereby causing long exposure to the air, the oil becoming oxidized and rancid, or at least objectionable in its aroma. Of this cod-liver oil the

Exportation.

annual exportation from Bergen is 4,000 to 5,000 barrels, or 125,000 gallons, most part to Germany, England, France, Italy, America, and Russia. Whether this oil, almost free from stearine, is more healthy than one containing it is difficult to decide, but it is evident that an oil with stearine can be sold at a much cheaper rate.

Old method of preparation.

"When there are no appliances for the manufacture of cod-liver oil by means of steam they proceed in the old way, which consists of placing the livers, unwashed and unclean, in open wooden vessels and leaving them exposed to the air; a sort of fermentation takes place, and the oil which exudes from day to day is removed. As no fire is employed, and the process is conducted in cold rooms, no stearine is produced, and the oil will keep bright indefinitely. In the outset this oil is of very fine quality, but after the vessels have been used from year to year the oil is more or less colored and tainted, even to rancidity.

Make of oil.

The finest quality of this oil is chosen in Bergen for medicinal use, and reported as '*oleum jecoris asselti flavum.*' About 15,000 barrels, of 100 kilos each, are sent to Germany, France, England, Holland, and Bel-

The expressed oil.

gium. After this oil is extracted the livers are subjected to pressure, and the resulting oil of a bad quality is exported for manufacturing purposes. The annual exportation is about 12,000 barrels. There is yet another sort, known as '*ol. jecoris asselti flav. fusium,*' which is prepared from livers left in barrels for several months. It often happens

The oil resulting from the delayed process.

that the fishermen are employed in fishing in distant waters and are compelled to leave the livers collected by them unattended to until their return. In the interval the livers undergo a peculiar kind of putrid fermentation, and the clear oil very readily separates from them, and in consequence is of a very clear deep-brown color; but, not being exposed to the inclemency of the weather, it has not become tainted. The best of this product is selected for medicinal use, and is that so much esteemed and employed by Dr. De Jong.

Annual production.

"The annual production is about 11,000 barrels, and a large portion of it is sent to France, where it is kept side by side with the French oil imported from the French fisheries in Newfoundland.

Oil by heat and pressure.

"After these several sorts of oil are extracted the livers are subjected to the influence of strong heat in iron pans, and afterwards to pressure, thus producing a thick oil of a dark color, used chiefly by the tanners of chamois skins. What now remains of the livers is used for manure.

Difference between the fish livers of the northern and southern districts.

"It may not be uninteresting to know that there is a decided difference between the oil produced by 'South of Norway' fish (Sondmore, Romsdalen, and Lofoden) and those of Finmarken; that in the south is more highly colored, and will keep clear at a lower degree of tem-

NORWAY.

perature than the oil prepared at Finmarken, which is whiter and more easily pressed. I think the reason is that in the case of the south fish, by long journeys down the Gulf Stream, and by a gradual nutritious feeding, their livers become more gradually and perfectly developed into a firmer fat, containing less stearine, while those of Finmarken are chiefly fed in the streams where are enormous quantities of a small, fat kind of fish (*'lodde,' Osmerus arcticus*), the result being that the growth of their livers is not of such a firm and perfect nature.

Cod-liver oil.

The fish livers of the northern and southern fishing districts.

"The first importations of new cod-liver oil are brought to Bergen in April, the second and third qualities at the end of May and June, and the other sorts in the harvest time, August.

"L. MONRAD KROHN,
"Bergen."

According to official statistical reports for 1877 it is stated that the number of barrels of cod-liver oil of all grades produced in Norway during the year was 130,600, valued at 9,664,400 fr.

Production of cod-liver oil in 1877.

PORTUGAL.

PORTUGAL.

Portugal sent a number of exhibits of honey, beeswax, olive oil, and twelve collections of chemical and pharmaceutical preparations, none of which presented sufficient novelty to require description.

Honey, wax, olive oil, etc.

The Société des Eaux Minérales de Vidago (Villa Real, a beautiful village situated in the fertile valley of the Oura) exhibited the product of their springs in bottles. It is an excellent alkaline water, similar to, and possibly superior to, that from the *grande grille* at Vichy.

Mineral waters.

The most extensive as well as the most important exhibit made by Portugal was that of wines, of which it produces the best and finest varieties used for medicinal purposes. Fine ports were shown in the wine section of the vintages of 1756, '90, '97, 1800, '10, '15, '20, '27, etc.; Duoro wines of the crops 1812, '15, '20, '30, '40. Madeiras of 1820, '43, '50, '45, '56, were sent to the Exposition from Funchal.

Wines.

In connection with the wine exhibit of Portugal it is interesting to notice the comparative amounts of the various wines exported to the United States and to Great Britain for the year 1876:

Exports to the United States and England respectively.

	Madeira.	Port.	Other wines.
To the United States	175	7,384	26,909
To Great Britain	13,084	2,057,628	95,825

The above figures represent deciliters (about 2½ gallons), and indicate pretty clearly that if the people of our country make use of as much Madeira and Port wine as they are accredited with, (!) they must get them at second or third

PORTUGAL.

hand and risk all the danger attending the handling of wines and liquors.

PORTUGUESE COLONIES.

PORTUGUESE COLONIES.

Benguela. India. Cape Verde.

These were well represented. Benguela sent dye-stuffs, copal, lichens for dyer's use. From India there came indigo and pistachio nuts; from Cape Verde, ground nuts, palm nuts, and soap made of pistache oil. In this section were exhibited many articles without botanical names, and which were not familiar in our commerce. The following were among those recognized: Gum arabic, seeds of *Ricinus (communis?)*, sassy bark, india-rubber, palm oil, and tobacco. At the entrance of the building stood a fine specimen of a young *Welwitschia mirabilis*, a singular plant consisting of two cotyledonary leaves, which become greatly developed in the course of years, sometimes acquiring a length of six feet.

RUSSIA.

RUSSIA.

Few exhibits.

This extensive country presented little of interest to the druggist or the apothecary; very few collections of raw materials were exhibited, and not many firms sent exhibits of pharmaceutical products.

Exhibitors.

V. Butzke, of Varonèga, exhibited oils of Russian anise and mint.

Chaguine & Prokofieff, of St. Petersburg employ 150 operatives to produce annually 7,500 quintals of egg and blood albumen and dried blood as manure.

The Imperial Botanical Garden of St. Petersburg sent a nice collection of pharmaceutical preparations extracted from vegetables.

V. Karpinski, of Warsaw, contributed pharmaceutical products.

F. Kuhn, of Moscow, had on exhibition a superior quality of protection for leather, rendering it supple and impermeable.

J. Sternfels, of Leal (Esthonia), oil of cumin.

R. Tetz, of Moscow, made elastic capsules by means of glycerine, for enveloping medicine, to the value of 75 to 80,000 rubles annually.

A. Waag & R. Repmann, of Doubrovka, exhibited etherial oils of mustard and peppermint.

SIAM.

SIAM.

Among the articles exhibited by His Majesty the King of Siam may be mentioned the few which follow, they

being the only ones relating at all to our part of the Exposition report: Black pepper, gum gutta, birds' nests, cardamom seeds, lac dye, gum benzoin of very fine quality, cinnamon, beeswax, *pistaches de terre*, tobacco, indigo, lemon juice, tamarinds, and preserved flowers. SIAM.

PERSIA. PERSIA.

His Majesty Nasr-Eddin Shah was the sole exhibitor from his kingdom. The articles of interest to the readers of this report were as follows: Indigo, madder, nutgalls, henna, cumin, saffron, tobacco from Shiraz for the nargileh and from Ourmiak for the pipe, opium, mallows, castor-oil beans, assafœtida, manna, and pistachio nuts. Wines from Shiraz and Kasbin were also exhibited. Exhibits.

Doctor Tholozan, physician to the Shah, while in Paris during the Exposition, gave the following information in regard to the mode of employing *henna* for coloring the hair in Persia: Dr. Tholozan on the mode of using *henna* in coloring hair.

"Hot water is added to a coarse powder of the leaves, and the paste is applied to the beard, the hair, and the nails (well washed previously). This is done in a vapor-bath. As the paste has to be kept constantly moist, this first application lasts an hour and a half to two hours; then the parts are washed with plenty of water. The henna gives an orange-red color, very beautiful on a white beard, so that many old men use it; but recently, with great personages, it has become more common to keep the beard white. Henna is very largely used, even by peasants. To change the reddish color to a fine lustrous black, the parts are coated, at the same sitting, with a paste formed of another powder—that from the leaves of a kind of indigo tree cultivated in Persia. This is called *reng;* it remains applied about two hours. The henna gives different colors, according as it acts on white, fair, or dark hair. It alters very quickly in moisture, and loses its properties in long sea-voyages. Experience seems to have proved that it gives suppleness to hair, but it causes it to whiten much sooner than usual. Fair-haired people always color their hair black, but the black is not so intense as that produced in persons of dark complexion. Skin, reddened and blackened with the two pastes, soon regains its natural color on being washed with soap and rubbed with the fingers, whereas the dye adheres firmly to the hair, which it penetrates. Reng is sometimes used alone, and gives a blue-violet color."

SPAIN. SPAIN.

Spain sent an abundant mineral-water product, no less than 53 exhibits of natural waters, to the Exposition, while she was represented by 20 pitiful pharmaceutical displays, a fact which might be taken to indicate that the Spaniard has more faith in natural remedies than in those fabricated by the hand of man. The number and variety of raw materials used by the druggist and pharmaceutist, how- Mineral waters.

SPAIN.

ever, were quite large, and their quality was in the main very good. In regard to olive oil and wine the Spanish section, after France, made the most extensive show and one which commended the admiration of all. Cork wood and cut corks formed another large item in the exports of this country. The following drugs were noticed in the collection: Sumac, caronbas, liquorice root and extract, cochineal, hops, saffron, anise, chamomile, carthamus, madder, woad, honey and wax, opium, ergot and ergotine, digitalis and digitaline, and cream of tartar made from the lees of wine.

Olive oil and wine.

Cork.

Drugs, dyes, wax.

MOROCCO.

MOROCCO.

This country sent a small collection of drugs and some plants useful in perfumery: Senna from *Cassia acutifolia*, *café nègre* from *C. occidentalis*, fruit of a *Datura*, galls, gums, colocynth, and a number of other crude matters that would be interesting to the visitor understanding the written Arabic language.

TUNIS.

TUNIS.

Cumin, fœnugreek, coriander, anise, and a long narrow variety of carraway seeds were among the few exhibits from this country. There were also pistachio nuts, henna used for coloring the nails and the teeth, and a few other specimens not worthy of special note.

GREECE.

GREECE.

This country was not represented by any pharmaceutical display.

SWEDEN.

SWEDEN.

H. A. Wulff.

H. A. Wulff, director of the Agricultural School of Applerum at Kalmar, contributed a collection of products derived from the distillation of wood, such as charcoal, tar, wood vinegar, creosote oil, and turpentine. He also sent dried specimens of the *Arbutus uva ursi*, and tanning material extracted from it.

Products of distillation of wood.

Fish-egg albumen.

T. O. Alsing, of Köping, showed albumen prepared from fish eggs.

Aseptine and Amykose Manufacturing Company of Upsala.

The Aseptine and Amykose Manufacturing Company of Upsala exhibited proprietary articles, as follows: Aseptine for the preservation of cooked food, aseptine (double) for the preservation of raw meat, aseptine for anatomical preparations. These preparations are said to owe their antiseptic and preservative qualities to boric acid, and the total production for the year 1876 amounted in value to 208,340

Antiseptic preparations.

frs., and there were employed in their fabrication 6,450 kilos of this acid. SWEDEN.

Beckman & Burmester. Beckman & Burmester, of Stockholm, exhibited a collection of drugs of the country and preparations made from them according to the formulæ of the Swedish pharmacopœia.

O. L. Björkbom. O. L. Björkbom, of Gothembourg, exhibited extract of malt.

Fish and Glue Gelatine Co., Ichthyocolla. The Fish Glue and Gelatine Manufactory of Lysekil had a number of very handsome specimens of ichthyocolla prepared from the entrails of fishes, which is quite transparent and soluble in cold water, and is specially adapted to the fining of wines.

Sébastine Manuf. Co. The Sébastine Manufacturing Company of Stockholm showed an imitation of their new explosive, *sébastine.** This substance is a mixture of nitro-glycerine, wood-charcoal, and explosive salts. The charcoal employed is carefully selected and prepared in a special manner not described, and serves to absorb and hold the explosive oil more completely than matters heretofore employed for that purpose. The explosive salts used furnish the oxygen necessary to burn completely the carbon of the mixture, and thus secures the conversion of the whole into gases.

Sébastine: an explosive.

Mode of using. In order to explode sébastine it is necessary to employ the usual detonating capsules, since on the application of fire in the shape of flame or an ignited body the compound simply burns away with considerable vigor, but without explosion.

Advantages claimed. The advantages claimed for this explosive are that it is less dangerous than others having nitro-glycerine for a base, the mass is dryer, and the explosive oil does not escape from it. The rapidity of its explosion is greater than that of ordinary dynamite, and the effect of its explosion much more considerable. The annual consumption of sébastine is about 70,000 kilos, and no untoward accident has happened in its use for five years.

Barnängens Tekniska Fab. The Barnängens Tekniska Fabrik of Stockholm exhibited extracts and odors for perfumery, toilet soap, and inks.

SOUTH AND CENTRAL AMERICA.

SOUTH AND CENTRAL AMERICA.

The exhibits from these countries consisted almost entirely of crude or raw materials, but the collections were quite extensive and included many articles not known in commerce, and as many of the specimens were labeled in the

*Explosive articles were not allowed to be brought into the Exposition building.

SOUTH AND CENTRAL AMERICA.

language of the country and designated only by their local names, very little information could be got as to their nature and uses, the custodians in most cases having no knowledges of them.

ARGENTINE REPUBLIC.

ARGENTINE REPUBLIC.

This country contributed the largest number of specimens of natural history, among which were vast numbers of medicinal plants, most of which are unknown outside of the country where they are produced, and are as yet untried.

Large number of native drugs unknown to commerce.

Anise; pimianta (allspice); coca; flaxseed; jaborandi; quebracha wood and resin; oil of potro (wild horse), and soap made from it; *Eucalyptus globulus*, and preparations made from it; preparations of matico; root of *Capii cati*, said to be very efficient as an anti-asthmatic and diuretic, and preparations made from it; resin of quebracha; elixirs of coca; guarana, and maté were exhibited from Buenos Ayres.

BOLIVIA.

BOLIVIA.

Here were a few exhibits of interest, among which may be mentioned cinchona barks, matico, and coca.

VENEZUELA.

VENEZUELA.

To judge from the collections of articles sent from this country to the Exposition, one must conclude that Venezuela, in many material respects, is in advance of some of

Fine collection of vegetable products.

the neighboring countries. There were in the collection many medicinal plants and parts of plants, woods, and other vegetable dye-stuffs and tanning materials, cinchona barks, and Rio Negro caoutchouc, copaiba, sarsaparilla, simarouba, tonqua beans, ceradilla, resin of cedar, and cochineal. Several pharmaceutical preparations of no special merit were exhibited.

GUATEMALA.

GUATEMALA.

From here were sent copalche bark (*Croton pseudoquina*); cascarilla; guaco; resin from native pines; copal, employed by the natives as incense; gum from *Rhizophora mang.*;

Barks, gums, cacao, wax, dyes, oils, etc.

liquidambar resin; caoutchouc wax from *Myrica cerifera;* vegetable suet from *M. sebifera;* several varieties of sarsaparilla; wild vanilla; wild cacao and divi-divi; cochineal; indigo; ambrette; beeswax; castor oil used in lamps, and a purer oil for medicinal use; cocoa-nut oil and corozo oil. No chemical or pharmaceutical preparations of note were exhibited.

HAYTI.

HAYTI.

Hayti exhibited a few articles of drugs and dyes, the most important of which were the following: Beeswax, cinchona, saffron, rhubarb, *Palma christi* oil (for lamps), annotto, curcuma, vitivert, orange peel, and bark of orange tree.

MEXICO.

MEXICO.

This country sent only essence of linaloe and resin of liquidambar.

NICARAGUA.

NICARAGUA.

Nicaragua had a modest display of articles in Classes 44, 45, 46, and 47, such as sarsaparilla, vitivert, annotto, copaiba, very fine cacao beans, liquidambar in reeds, caoutchouc of various qualities, some of which was very select, gutta percha, vegetable wax of a green color, nacascola and nancite barks for tanning, cinchona barks, cashew nuts (labeled St. Ignatius beans!), copalche bark, indigo, starch, and crocodile musk.

Cacao, gums, barks, nuts, dyes, etc.

SALVADOR.

SALVADOR.

This was a well-arranged collection, representing the fauna and flora of the country. The commercial commodities in the line of drugs were indigo, wax, vegetable aromatic resins, cochineal, purified oil of cocoa, *baumes du Salvador*, *quina du Salvador*, various pharmaceutical products, and mineral waters.

Dyes, oils, wax, resins, etc.

URUGUAY.

URUGUAY.

The exhibits from this little republic were not numerous, and were similar to those from its neighbor, Buenos Ayres.

PERU.

PERU.

From Peru there were specimens of nitrate of soda, of iodine, and a collection of minerals of the country, cochineal; cinchona barks were also exhibited, as well as coca and vanilla.

SWITZERLAND.

SWITZERLAND.

This rugged little republic sent no crude drugs to the Exposition, but she was well represented in a few of the branches of chemical manufactures, notably that which is concerned in the production of artificial coloring matters. The following exhibits were considered worthy of notice:

V. Andreæ.

V. Andreæ, of Fleurier, exhibited a choice selection of pharmaceutical and *hygiéniqu*ᴇ preparations, consisting principally of extracts of Alpine plants.

SWITZERLAND.

J. Baumgartner. J. Baumgartner, of Mollis, had a very superior glue or cement, in the state of powder, alleged to be made of caseine, which is quite strong and said to resist the action of water.

Novelties in color chemistry. Bindschedler & Busch, A. Gerber & Uhlman, L. Durand & Huguenin, Louis Freund, and J. R. Geigy, of Basle, and P. Monnet & Co., of La Plaine, near Geneva, all had magnificent displays of all the novelties in color chemistry. Their exhibits were of extraordinary beauty, and presented the greatest interest to the chemist and dyer. Attention is recalled to them in another part of this report.

L. Imhof, non-poisonous colors. Imhof (Louis), of Aarau, had a very important exhibit of coloring matters free from poison or other offensive ingredients, especially intended for coloring confections.

C. Jetzler, Regenerated manganese. C. Jetzler, of Schaffhausen, exhibited "regenerated" manganese produced by a new process, and showed a plan of the apparatus used by him for performing the operation.

A. O. Mathey, Diamantine. A. O. Mathey, of Neuchâtel, has invented a polishing material for watchmakers, which he calls diamantine. He claims that it gives quickly, even on untempered steel, a black polish, and that it never leaves scratches. The composition is not given, but it is regarded as consisting of alumina in an excessively fine but at the same time crystalline state. So-called boron diamonds and artificial carbon diamonds were also exhibited by the same.

Artificial diamonds.

A. Guyot-Lupold. A. Guyot-Lupold, of Ecreuses-Locle, exhibited diamantine, powder of rubies, and artificial black diamonds for drilling hard rocks. These artificial stones cost about one-fourth the price of the real black diamond, and supersede them for most purposes. They are distinguished from the latter, however, by the absence of crystalline appearance, and the formation of a black instead of a yellow powder when crushed.

Artificial gems for drilling and polishing.

Dr. Muller-Jacobs. Dr. A. Muller-Jacobs, of Zurich, exhibited a succedaneum for oil in the production of the turkey-red dye, with which he claims to be able to produce absolutely fast and very fine violets and reds in from three to four days.

Rothenhäusler. Rothenhäusler, of Rorschach, sent a specimen of what he claims to be "Véritable huile russe pour le cuir."

Dr. G. Wander. Dr. G. Wander, of Berne, had on exhibition bonbons of malt, sugar of malt, pure extract of malt, and malt combined in various pharmaceutical preparations.

UNITED STATES.

UNITED STATES.

The collections of drugs, chemicals, pharmaceutical preparations, etc., sent from the United States were well displayed in handsome show-cases, on well-arranged systems of

shelves, and in large and expensively constructed kiosques, some of which seemed to be out of proportion to the limited space allotted to our section. The exhibits were all well arranged for examination, and attracted much attention, principally on account of the number and magnitude of the collections of pills conspicuously displayed. The United States exhibits in Class 47 differed in some respects from those of most other countries. While Austria, Belgium, France, England, etc., contributed almost exclusively manufactured articles, and the English, French, and Dutch colonies, China, South and Central America sent crude drugs and raw materials, the United States sent full assortments of indigenous drugs and *materières premières*, as well as numerous manufactured products in the various departments of chemistry and pharmacy.

UNITED STATES.

Exhibits well arranged.

Pills predominating.

Assortment of *materières premières* and manufactured products.

The most extensive and complete collection of indigenous drugs in the whole Exposition was the contribution made by the Philadelphia College of Pharmacy. This collection was said to represent the entire vegetable *materia medica* growing in the United States; the specimens presented the appearance of having been selected and prepared with great care, and they were displayed in a very neat and modest manner. It was said that this collection was to be donated, at the close of the Exposition, to the École Supérieure de Pharmacie de Paris.

Philadelphia College of Pharmacy.

Complete collection of the vegetable *materia medica* of the United States.

Tilden & Co., and McKesson & Robbins, of New York, showed well-selected specimens of drugs derived from the vegetable kingdom; the first-named firm, along with their raw materials, exhibited solid and fluid extracts made from the vegetables they exhibited. They also displayed a very great variety of sugar-coated pills of fair quality. The latter firm, besides the vegetable drugs referred to, contributed a collection of choice essential oils of American production.

Tilden & Co.

McKesson & Robbins.

Drugs, extracts, and pills.

Wm. R. Warner & Co., of Philadelphia, presented a large assortment of sugar-coated pills and granules, which were very handsome as specimens of the art of *dragée* manufacture. They were commended for their uniformity in size and finished surface.

W. R. Warner & Co., Sugar-coated pills.

Hance Brothers & White, of Philadelphia, had a fine display of chemical and pharmaceutical preparations, including handsome crystals of monobromide of camphor, salts of berberine, nitrite of amyl, a variety of fluid extracts in large bottles, and a "line" of sugar-coated pills in large quantities and of good appearance. The coating of pills with sugar has developed enormously of late years in the United States, and it has become the largest producer of this class

Hance Bros. & White, Chemical and pharmaceutical preparations.

Sugar-coated pills.

UNITED STATES.

of products in the world. Originating in France many

Hance Bros. & White.

years ago, the art of sugar-coating of confectioner's *dragées* became almost universal and very popular; it was taken up

Sugar-coated pills.

by the apothecaries ostensibly for the purpose of disguising the nauseous taste of drugs. From France the practice extended to other countries and found its principal development in this country, where it has almost replaced the old style of pill, seriously threatening the occupation of the regular pharmacist in the practice of his calling and the usefulness of the national pharmacopœia.

Advantages and disadvantages of the new method.

This new art has been found not only to cover the disgusting taste of the drug contained in the pill, but unfortunately in many instances it also serves to cover light weights, inferior medicines, etc., as has been repeatedly shown by critical analyses made and reported by committees of the American Pharmaceutical Association during the past ten years. The medical and pharmaceutical professions in Europe do not seem to look with much favor upon this style of elegant pharmacy.

Wyeth & Bro.,

Wyeth & Bro., of Philadelphia, exhibited medicinal

Elixirs and powders.

elixirs, compressed powders, dialyzed iron, saccharated pepsin, and some other pharmaceutical preparations and specialties of very handsome and prepossessing appearance and excellent quality, all of which were in graceful bottles well adapted for the purposes of an exhibition, and inclosed in a large and handsome show-case.

Emil Scheffer, of Louisville, the originator of saccharated pepsin, was not represented.

The display of pills which attracted the most attention

Schieffelin & Co.

and excited the most interest was that of W. H. Schieffelin & Co., of New York. Their vitrine was not large, but it was exceedingly neat, tasteful, perfectly finished, and, like the collection of the Philadelphia College of Pharmacy, it was modest and inviting, and their exhibit merited the compli-

Superior coated pills.

ments that were passed upon it. Their assortment of pills was extensive and handsome. They had been coated cold

A thin, transparent, soluble coat.

and in a soft state with a thin, transparent, and soluble coating, which adds practically nothing to their size or weight while it protects the interior from the atmosphere and prevents hardening of the mass by evaporation. This collection is an example of perfection in pill manufacture. The idea of enveloping pills in a coating of gelatine, sugar, gum, resin, balsam, etc., is old, and has been practiced with varying success for a century; but complete success has never crowned the attempts to secure a thin, transparent,

quickly soluble, and perfectly protective coating for pills until the subject was taken up by Schieffelin & Co.

Bolen & Byrne, Mineral waters and dispensing apparatus.

Artificial mineral waters and apparatus for preparing and dispensing them were handsomely displayed by Bolen & Byrne, of New York. The qualities of their products were tested with approval and great satisfaction by the numerous thirsty visitors to the United States section of the Exposition.

De Mortie & Co., T. D. Driscoll. Oil of sassafras.

De Mortie & Co., of Burkeville, and T. D. Driscoll, of Well Water, Va., exhibited fine specimens of oil of sassafras, produced in large quantities and at cheap rates in the States of Maryland and Virginia, whence it finds its way to market principally in Baltimore.

Forstall & La Rose., Turpentine.

Forstall & La Rose, of New Orleans, exhibited spirits of turpentine and other products from the Southern pine.

Fritzsche Bros., Essential oils.

Fritzsche Brothers, of New York, sent a good collection of essential oils of peppermint, etc.

Hale & Parshall, Essential oils.

Hale & Parshall, of Lyons N. Y., exhibited specimens of American essential oils, some of which were turbid from some cause not explained.

H. G. Hotchkiss, L. B. Hotchkiss, Oil of peppermint.

H. G. Hotchkiss, of Lyons, and L. B. Hotchkiss, of Phelps, N. Y., had large displays of fine oil of peppermint. The oils of these makers has acquired a world-wide reputation, and is quoted in the market reports as commanding the highest prices of any peppermint oils.

Keith & Co., Oil of erigeron.

Keith & Co., of New York, exhibited a good specimen of oil of erigeron.

Exhibits of essential oils.

McKesson & Robbins, New York; Blackmar & Allerton, Newark, N. J.; A. M. Todd, Nottawa, Mich.; the United States Department of Agriculture, Washington; and Wolf Brothers & Keech, of Centreville, Mich., all exhibited fine specimens of essential oils distilled from American plants, among which may be mentioned oils of erigeron, of peppermint, of spearmint, of wormwood, of tanzy, etc.

Fine specimens of oil of orange flowers and of petit-grain were exhibited in the building of the United States Agricultural Department, in the United States annex, but the name of the producer was not obtained by the reporter.

Geo. J. Faller. Sewing-machine oil.

Geo. J. Faller of Philadelphia, exhibited sewing-machine oils.

Frazer Lubricator Co., Axle-grease.

Frazer Lubricator Company, of New York, had specimens of their axle-grease on exhibition.

R. J. Chard, Lubricine.

R. J. Chard, of New York, subjected his lubricine to the test of actual trial, in connection with his lubricating cups, on some heavy steam-machinery in the United States sec-

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tion, and the results of the test were said to be quite satisfactory.

R. Freeland, Soaps.

Robert Freeland, of Boston, exhibited soaps manufactured by a rapid and economical process. They presented the external appearances of the best articles of their class.

C. L. Hauthaway & Sons, Blacking.

C. L. Hauthaway & Sons, of Boston, displayed excellent blacking and leather dressing.

W. Dreydopple, Borax soap.

William Dreydopple, of Philadelphia, erected a large and handsome monument made of his borax soap. This product is said to possess many advantages over ordinary soaps for bleaching woolen goods and fabrics made of material of a similar nature.

Adams & Shaler, D. M. Young, Bark extracts.

Adams & Shaler, of New York, and D. M. Young & Co., of Boston, exhibited specimens of extract of bark for tanning.

F. W. Hurtt & Bros., Perfumery, etc.

F. W. Hurtt & Bros., New York, exhibited chemicals, perfumes, and toilet articles.

Leonard & Ellis, Lubricating oils.

Leonard & Ellis, New York, displayed, in quite handsome style, lubricating oils.

F. S. Pease, Lighting and lubricating oils.

F. S. Pease, Buffalo, N. Y., had a large and attractive collection of illuminating and lubricating oils on exhibition.

Mellor & Rittenhouse, Extract of licorice.

Mellor & Rittenhouse, Philadelphia, exhibited a case of very superior extract of licorice root. They also included in their vitrine a specimen of jervia and one of glycyrrhizine in its ammoniacal combination.

Restorff, Bettmann & Co., Leather dressing.

Restorff, Bettmann, & Co., New York, showed their leather dressing and shoe bronze.

Smith's Homœopathic Pharmacy, "Alkathrepta."

Smith's Homœopathic Pharmacy, New York, with homœopathic globules had samples of "alkathrepta" (a preparation from cacao) on exhibition.

W. Tilden, & Stokes; Valentine & Co., Varnishes.

Tilden, (Wm.), & Stokes and Valentine & Co., New York, displayed a variety of very fine varnishes. The writer was informed that the varnishes of the latter firm had been used on some of the finest carriages of both American and European make in the Exhibition, and had received very flattering testimonials.

Tunyoap Manuf. Co., Leather dressing.

The Tunyoap Manufacturing Company, Boston, exhibited a new product resulting from the "partial oxidation" of a waste material from petroleum refineries, which is at present applied as a dressing to render leather soft, durable, and water-proof.

Seabury & Johnson, Plasters.

Seabury & Johnson, New York, displayed a large assortment of medicated and other plasters suited to surgical uses. They are made of the rubber plaster composition, which is claimed to possess many advantages over the old and official plaster. The appearance of this exhibit indicated that

great care and taste had been exercised in the fabrication of the products shown. UNITED STATES.

Exhibitors of chemical products from the United States were as follows: Exhibitors of chemical products.

Anthony Pirz, Long Island City, who sent handsome crystals of acetate of lead. Anthony Pirz.

Hance Brothers & White, Philadelphia, besides pharmaceutical products exhibited a collection of products of chemical manufacture, such as monobromide of camphor, nitrate of amyl, etc., all of which presented a fine appearance. Hance, Bros. & White.

Henry Bower, Philadelphia, showed yellow prussiate of potash, sulphate of ammonia, and pure concentrated glycerine. The latter was very dense, colorless, free from odor, and adapted in every respect for all the uses of a pure glycerine. Henry Bower.

H. J. Baker & Bro., New York, exhibited beautiful specimens of pure castor-oil, borax, refined saltpeter, camphor, and purified epsom salts. They were all prepossessing in appearance, and were doubtless of fine quality. H. J. Baker & & Co.

Charles T. White & Co., New York, made a fine display of some of the leading articles manufactured in their laboratory, handsome specimens of morphia and its salts, strychnia in large bold crystals, bromide of potassium, etc., all of which indicated great care in their preparation and exceptional purity. C. T. White & Co.

A new product from petroleum called vaseline was exhibited by the Chesebrough Manufacturing Company, New York, and a similar substance called cosmoline was shown by E. F. Houghton & Co., Philadelphia. Apollo fat, also called vaseline, was exhibited by Gartemberg, Lauterbach, & Goldhammer in the Austrian annex. Chesebrough Manuf. Co., Vaseline. E. F. Houghton & Co., Cosmoline.

These substances—vaseline, cosmoline, and apollo fat—are claimed to have many properties in common, and, from all the information obtained in regard to them, they are supposed to be similar products or educts from petroleum, being mixtures of various hydrocarbons existing in or formed out of it, obtained by evaporation at a high temperature and repeated hot filtrations through animal charcoal. They are said to be free from chemicals of every description, odorless, or nearly so, especially when recently prepared, and grading in color from almost white to a yellow or orange tint, occasionally in the colored samples presenting a strong fluorescence. The latter property was observed to be very pronounced in the case of the article called cosmoline. Their consistence varies from that of a thick oily fluid to that of Lubricators made by peculiar processes from petroleum.

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a lardy mass, and they possess lubricating qualities in a very high degree. They are said to be incapable of saponification, dissociation by hot steam, and not to become rancid like fats. The vaseline of the Chesebrough Company is nearly white, and is said to be a succedaneum for fats as a basis for ointments and for other pharmaceutical preparations, and well adapted to the uses of the perfumer in the process of *enfleurage* of pomatums. Houghton & Co., besides cosmoline, which is recommended for the same purposes as vaseline, make a preparation which they call cosmolubric, and laud it highly as an efficient lubricant and anti-incrusting agent for use in steam-boilers.

Vaseline and cosmoline.

These substances are comparatively new products of chemical industry, possessing valuable properties suiting them for many useful applications in the arts, and they will doubtless come into general favor in the near future.

Exhibits transferred from Class 47 to other classes.

The following exhibitors are placed in Class 47 in the United States Official Catalogue issued by the Commissioner-General, but, by decision of the jury of that class, were declared not to belong to it, and consequently were not included in the examinations by that jury:

R. J. Chard: Automatic lubricating cups. (The lubricine of this exhibitor was not discovered until after the visits of the jury.)

Austin G. Day: Kerite insulated telegraph wire and cables.

J. P. Evans & Co.: Flaxseed and linseed oil.

Oregon State Commission: Raw and boiled linseed-oil and oil-cake.

Philadelphia College of Pharmacy: Collection of vegetables.

Wallace Brothers: Plants, herbs, and flowers.

Recompenses to exhibits in Agric. Dept. annex.

All the exhibits in Class 47 that were displayed in the United States Agricultural Department annex were credited to that department and the recompenses rewarded accordingly.

THOMAS E. JENKINS,
Additional Commissioner.

MINING INDUSTRIES.

JAMES D. HAGUE.

[Extract from the Official Classification.]

CLASS 43.—MINING AND METALLURGY.

Collections and specimens of rocks, minerals, ores. Ornamental stones. Hard stones. Refractory substances. Earths and clays. Various mineral products. Raw sulphur. Rock salt; salt from salt springs.

Mineral fuel: various kinds of coal, coal dust, and compressed coal. Asphalt and rock asphalt. Bitumen. Mineral tar. Petroleum, etc.

Metals in a crude state: pig-iron, iron, steel, cast-steel, copper, lead, silver, zinc, etc. Alloys.

Products of washing and refining precious metals, of gold-beating, etc.

* * * * * * *

[NOTE.—The following report refers to only a portion of the subjects in the class.]

[In forwarding this report to the Department of State, Mr. Hague offered an explanation, under the date of December 26, 1879, from which the following is extracted:]

"When I had the honor of accepting, nearly two years ago, the appointment of Additional Commissioner to the Paris Exposition of 1878, I confidently expected to have fully discharged, long before now and to the best of my ability, all the obligations incurred by such acceptance.

"Among these obligations, as I found after arrival in Paris, was the preparation of a report upon Group V of the Exposition. A brief inspection of the catalogue, however, showed this group to be so comprehensive in its range, comprising exhibits of products so diverse in character, that, after consultation with the Commissioner-General, I determined to limit my official investigation to some of the exhibits of Class 43, embracing ores, minerals, and the crude products of mining industry.

"It was my good fortune to secure the aid of my friend, Mr. George F. Becker, of the United States Geological Survey, and lately of the University of California, in making the necessary examination at the Exposition, and he has contributed largely to the paper which I herewith submit."

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MINING INDUSTRIES.

I.

RANK OF THE GREAT MINING COUNTRIES.

PRODUCTION AND RANK OF THE GREAT MINING COUNTRIES OF THE WORLD, 1876.

Relative rank of the great mining countries of the world, 1876.

In the Belgian exhibit at Paris was displayed an interesting chart showing the total quantities of coal and base metals produced in the principal countries of the world, the quantities per square kilometer, and the rank occupied by each for the year 1876. Such a general statement seems desirable as an introduction to the following papers, and the figures used in plotting the chart have been employed for that purpose.

Units; *tonnes* of 2,205 pounds.

In the original, *tonnes* of 1,000 kilos, or 2,205 pounds, and square kilometers are the units employed. The unit of weight is so near our own ton that its conversion seems unnecessary.

Square kilometers.

The products per square kilometer have been reduced to yield per square mile by multiplying by 2.6. Gold and silver have also been added to the list from data obtained from Dr. A. Soetbeer's memoir, "*Edelmetall-production, Petermann's Mittheilungen, Ergaenzungs-Heft, No.* 57, 1879."

COAL.

Countries.	Total product in 1876.	Countries.	Product per square mile.
	Tonnes.		*Tonnes.*
1. Great Britain	135,477,282	1. Belgium	1,264
2. Prussia*	43,451,371	2. Great Britain	1,118
3. United States	41,000,000	3. Prussia	325
4. France	17,047,762	4. Austria	101
5. Belgium	14,329,578	5. France	88
6. Austria	11,867,715	6. United States	10
7. Russia	1,708,512	7. Spain	2.6
8. Spain	101,522	8. Russia	0.78
9. Sweden	96,674	9. Sweden	0.50

Product of coal in various countries, and per square mile.

*Among the German states Prussia only is represented in the tables, because at the time when the figures were compiled the mineral statistics of the German Empire had not been published.

Relative product of various countries.

IRON ORE.

Iron ore.

Countries.	Total product in 1876.	Countries.	Product per square mile.
	Tonnes.		*Tonnes.*
1. Great Britain	17,111,049	1. Luxembourg	1,204
2. United States	4,500,000	2. Great Britain	140
3. France*	3,081,026	3. Belgium	22
4. Prussia	2,072,250	4. Prussia	15
5. Russia	1,935,187	5. France	15
6. Luxembourg	1,196,729	6. Austria	4.7
7. Sweden	787,092	7. Sweden	4.4
8. Austria	554,965	8. Spain	2.3
9. Spain	436,586	9. United States	1.3
10. Belgium	269,206	10. Russia	0.5

* Figures for 1873 (latest official statistics).

PIG-IRON.

Pig-iron.

1. Great Britain	6,644,895	1. Luxembourg	231
2. United States	2,093,236	2. Great Britain	55
3. France	1,449,537	3. Belgium	44
4. Prussia	1,324,338	4. Prussia	10
5. Belgium	490,498	5. France	7.8
6. Russia	427,548	6. Austria	2.3
7. Sweden	348,257	7. Sweden	2.1
8. Austria	273,045	8. United States	0.5
9. Luxembourg	180,500	9. Spain	0.3
10. Spain	56,462	10. Russia	0.2

BAR-IRON.

Bar-iron.

1. United States	1,922,000	1. Great Britain	15
2. Great Britain	1,822,704	2. Luxembourg	7.3
3. France	875,000	3. Prussia	6.0
4. Prussia	814,000	4. France	4.2
5. Belgium	390,000	5. Belgium	3.6
6. Russia	304,056	6. Sweden	1
7. Sweden	167,719	7. United States	0.5
8. Spain	41,464	8. Spain	0.2
9. Luxembourg	7,418	9. Russia	0.16
10. Austria*	.....	10. Austria*	.....

STEEL.

Steel.

1. Great Britain	545,560	1. Belgium	6.5
2. United States	525,996	2. Great Britain	4.4
3. France	254,191	3. United States	1.4
4. Prussia	120,500	4. France	1.3
5. Belgium	75,258	5. Sweden	1
6. Sweden	18,785	6. Prussia	0.94
7. Russia	8,945	7. Spain	0.16
8. Spain	2,720	8. Russia	0.018
9. Austria*	.....	9. Austria*	.....

* Not stated in the official statistics.

LEAD.*

Lead.

1. Spain	101,522	1. Belgium	0.614
2. Prussia	70,207	2. Spain	0.528
3. Great Britain	59,606	3. Prussia	0.523
4. United States	58,125	4. Great Britain	0.491
5. France†	21,339	5. France	0.104
6. Belgium	6,963	6. Austria	0.036
7. Austria	4,291	7. United States	0.016
8. Russia	1,683	8. Russia	0.0005

* In the absence of recent official statistics, Italy and Greece do not appear in this table, in spite of their importance as lead-producing countries. The former produces about 9,000, the latter about 8,000 tons.

† Figure for 1872 (latest official statistics), including the wrought metal.

ZINC.*

Relative product of various countries.

Countries.	Total product in 1876.	Countries.	Product per square mile.
	Tonnes.		*Tonnes.*
1. Prussia	83,634	1. Belgium	4.420
2. Belgium	49,960	2. Prussia	0.624
3. France	17,434	3. Great Britain	0.546
4. United States	16,091	4. Austria	0.338
5. Great Britain	6,747	5. Spain	0.156
6. Russia	3,990	6. France	0.078
7. Austria	3,979	7. United States	0.052
8. Spain	2,940	8. Russia	0.018

Zinc.

*According to non-official statements, crude metal.

GOLD.

[Average of the five years 1871 to 1875.]

Countries.	Total product.		Countries.	Product per square mile.
	Kilos.	*Dollars.*		*Dollars.*
1. Australia	59,900	39,812,000	1. Australia	18.29
2. United States	59,500	39,545,000	2. United States	18.07
3. Russia	33,380	22,184,000	3. Bolivia	2.66
4. New Grenada	3,500	2,326,200	4. Russia	2.65
5. Mexico	2,020	1,824,500	5. Mexico	1.76
6. Bolivia	2,000	1,329,264	6. New Grenada	0.80
7. Brazil	1,720	1,143,200	7. Brazil	0.36

Gold.

SILVER.

[Average of the five years 1871 to 1875.]

Countries.	Total product.		Countries.	Product per square mile.
	Kilos.	*Pounds troy.*		*Ounces troy.*
1. Mexico	601,800	1,612,400	1. Mexico	25.45
2. United States	564,800	1,513,200	2. Germany	22.04
3. Bolivia	222,500	596,140	3. Chili	19.95
4. Germany	143,080	383,350	4. Bolivia	14.31
5. Chili	82,200	220,240	5. United States	6.00
6. Peru	70,000	187,550	6. Austria-Hungary	5.16
7. Austria-Hungary	38,550	103,290	7. Peru	4.50
8. Russia	11,495	30,800	8. Russia	0.04

Silver.

II.

FRANCE.

FRANCE AND THE FRENCH COLONIES.

FRANCE.*

Gaulish mines and knowledge of metals.

The mining industry of France is of ancient origin. Before the Roman conquest the Gauls were familiar with gold, silver, copper, tin, bronze, and iron. Under the Roman rule the exploitation of metalliferous mines gave rise to some very important and extensive works, which were abandoned, however, at the time of the Northern invasion, to be resumed again by the Saracens in the Pyrenees, the Alps, and some other districts; but it was only about the end of the eleventh century that the mines of France assumed any real importance. In the thirteenth century the mines were again abandoned, in consequence of the long-continued wars, which disturbed the country and dispersed the laborers. They were not reopened until the commencement of the sixteenth century, shortly after the discovery of America, when greater depths in the mines were made accessible by the opening of deep-drainage tunnels, and ores of low value were utilized by improved processes of crushing and separating the richer mineral from the worthless gangue. Operations were again arrested by the Thirty Years' War and incidental disturbances. In the eighteenth century, and particularly under Louis XVI, some prosperous mining operations were prosecuted in Brittany, the Pyrenees, and in Central France. The introduction of powder and of improved mechanical appliances increased the effect of labor, and resulted in the working of the mines at greater depths. But this prosperity was only temporary; the creation of a corps of mining engineers (1781) and of a school of mines (1783), and the law of April 1, 1810, which defined and assured the rights of ownership in mines, did not succeed in reviving the industry in metal mining of France, which (not considering iron) to-day employs only about 4,000 laborers, producing annually a value of only 6,356,607 fr. It is to be remarked that, excepting the ores of iron, few of the metalliferous deposits of France are sufficiently rich, and at the same time sufficiently accessible, to repay exploitation.

Roman exploitation.

The Saracens.

Internecine broils of the middle ages.

Improved methods.

Period of Louis XVI.

Introduction of gunpowder.

Few paying mines in France, except iron.

* Mainly from the "*Statistique de l'Industrie Minérale*" and other official sources.

FRANCE.

Since the year 1791 there have been granted 1,233 mining concessions of every sort. Of these 615 were for combustible materials, 297 for ores of iron, 225 for metals other than iron, 96 for sundry substances. In 1872 there existed 611 concessions of mines of coal, anthracite, and lignite, covering a superficial area of little more than 5,418¼ square kilometers (about 2,092 square miles); 251 concessions of iron mines, with a superficial area of 1,187.69 square kilometers (about 458 square miles); and 222 concessions of mines of sundry metals—embracing an extent in area of 2,867.79 square kilometers (about 1,107 square miles). At the end of 1875 the number of concessions of mines in France had increased to 1,256, of which 613 were for coal or mineral fuel, 284 for iron, 244 for sundry metals, and 615 for various substances. Besides these there are a great number of quarries from which are obtained materials for construction, building-stones, marbles, clays, refractory earths, phosphates, ochers, talc, barytes, sulphur, rock-salt, alum, etc.

Mining concessions.

In 1872.

In 1875.

Ores of copper are rare in France. Such as are treated there metallurgically are brought from Bolivia, Algeria, and Italy; the supply of metal from these sources, and from the remelting of old stock, being supplemented by importations of copper from England, the United States, and Chili, especially the last-named country.

Copper ores.

In addition to the domestic supply of lead ores in France are those sent from Sardinia, Spain, and Algeria; while lead is imported in the pig from England, Spain, and Belgium.

Lead ores.

Ores of zinc are mined and treated to some extent in the south of France; the principal portion of the zinc ores treated in France, however, come from Spain, Germany, and Belgium. The crude metal is also brought from Silesia and other sources for manufacture.

Zinc ores.

The supplies of manganese, mercury, antimony, cobalt, tin, and the precious metals employed in the industries of France come almost altogether from foreign countries. Within recent years large quantities of nickel ores have been sent to France from New Caledonia, one of the French colonies of the South Pacific.

Manganese, mercury, antimony, tin, gold, silver, etc., imported.

The most important elements in the mining industries of France are iron and coal. The iron deposits have been worked since the time of the Gauls in many localities where the ore was found sufficiently rich to be reduced in small charcoal-hearths. This industry continued to increase steadily from the end of the sixteenth century, when it first assumed a real importance, until 1860, when the necessity of

Iron ore.

Treaties of 1860.

FRANCE.

competing with foreign products, to which commercial treaties had opened the country, brought about the importation of richer ores from a distance and even from abroad, with which, by the use of coke, it was possible to produce iron comparable in quality to that made with charcoal at a higher cost.

Importation of richer iron ores.

Substitution of richer foreign ores for the poor native ores.

This change in the metallurgical industry, together with the gradual substitution of steel for iron, has diminished the production of iron ores of low tenor, which are of very abundant occurrence in France, by diverting the attention of metallurgists to the richer deposits of the Pyrenees and the Alps, where extensive and important operations have been undertaken. Notwithstanding this, the importance of foreign ores for treatment in France appears to have increased somewhat in spite of the loss of Alsace and Lorraine.

Importation and consumption of iron ores in France.

The following table shows the importation of iron ores into France, in juxtaposition with the consumption for a series of years. The French *tonne* is 1,000 kilos, or 2,205 lbs. avoirdupois.

Year.	Importation.	Consumption.
	Tonnes.	*Tonnes.*
1863	117,567	3,292,486
1872	438,734	3,105,402
1873	720,508	3,418,779
1874	801,249	3,104,534
1875	832,875	3,159,076

Sources of foreign iron ores.

The sources upon which France draws for iron ores may be seen from the following table:

Country.	1873.	1874.	1875.
Algeria	267,332	336,282	333,807
Spain	175,591	186,168	150,884
Belgium	120,932	92,934	132,373
Italy	123,081	145,076	129,211
Other countries	33,572	40,789	36,600
Total	720,508	801,249	832,875

Coal.

Coal was mined at Roche-la-Molière, in the valley of the Loire, as early as 1321. In the sixteenth century there were exploitations in coal at Brassac and at Grand'-Combe.

Early development of coal mining.

At the end of the seventeenth century coal mining was developed at Decize, and French coals were sent to Paris in competition with English coal, which had been used there since 1520. During the eighteenth century the coal-mining industry of France assumed considerable importance. In 1720 the Vicomte Désandroins discovered coal at Fresnes, and in 1734 at Anzin. The first steam-engine was brought

The first steam-engine for mine draining in France.

FRANCE.

Coal.

to France in 1732, and employed in draining the mines of Anzin. At the present day the collieries of the *Compagnie des Mines d'Anzin* are the most important in France, their annual production being about 2,000,000 tonnes, or more than one-eighth of the entire product of the country. In 1789 the coal mines of sixteen provinces produced 240,000 tonnes, a quantity about equal to the coal importation of that time. Since then the production has increased 66-fold, while the importation has increased about 32-fold, the latter being now only about 48 per cent. of the native production, to which it was about equal in 1789, and only 33 per cent. of the total consumption, of which it then formed 53 per cent.

Compagnie des Mines d'Anzin.

Increase of production: 1789–1875.

The French importation, exportation, and consumption of coal for three years were as follows, in tonnes:

Importation, exportation, and consumption: 1873–1875.

	Importation.	Exportation.	Consumption.
1873	8,028,660	694,670	24,702,380
1874	7,433,470	747,050	23,417,530
1875	8,282,220	671,580	24,657,530

Sources of foreign coal.

More than one-half the coal imported comes from Belgium, about one-third from England, and an eighth from Germany. Of the exported coal nearly two-fifths goes to Italy.

The manner in which coal is consumed is always an interesting question from a technological point of view. The following are the data for France:

Mode of consumption of coal.

How consumed.	1873.	1874.	1875.	
	Tonnes.	*Tonnes.*	*Tonnes.*	*Per cent.*
Mines	1,042,230	1,110,960	1,174,290	24.58
Smelting works	4,969,859	4,699,509	4,880,383	
Railways	2,108,471	2,031,119	1,980,773	8.03
Ocean steamers	327,700	281,500	309,500	1.26
River steamers	71,900	61,800	68,000	0.27
In other ways (by difference)	16,182,220	15,226,642	16,238,084	65.86
Total	24,702,380	23,417,530	24,657,530	100.00

By reference to the articles on Great Britain and Austria it will be seen that the percentage consumption varies greatly in the three countries.

Mean price.

The mean price of coal and lignite has risen steadily during the period covered by the table. It was as follows:

	Francs.
In 1863	11.31
In 1867	12.23
In 1872	13.46
In 1875	15.93

These are practically prices of coal, to the production of which that of lignite bears a very small proportion.

Products of mines.

Table of the products of the French mines.

Products of the mineral industry.	1863.	1867.	1872.	1875.
Combustible minerals:	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
Coal	10,447,022	12,464,659	15,359,195	16,504,635
Lignite	262,547	274,029	443,319	452,205
Total	10,709,569	12,738,688	15,802,514	16,956,840
Peat	421,342	326,744	324,323	317,748
Raw iron ore	4,009,624	3,279,395	3,081,026	2,505,870
Metallic ores:				
Copper	70,870	75,508	7,653	8,698
Lead	305	220	817	.....
Lead and silver	106,629	89,309	77,518	*8,728
Antimony	36	100	173	223
Manganese	4,239	4,434	10,315	9,016
Nickel and cobalt	23	.....	.....	.....
Zinc	.....	550	202	4,088
Tin	.....	.....	273	1,000
Iron pyrites	28,717	40,933	45,813	131,154
Iron and copper pyrites	.....	.....	89,539	.....
Total	210,819	211,554	232,298	162,907
Various minerals:				
Bauxite and aluminous minerals	.....	1,200	1,600	2,669
Sulphur	.....	.....	4,563	4,900
Bitumen and bituminous schists	147,377	163,932	208,130	140,696
Graphite	10	.....	1	.....
Rock-salt	168,364	212,767	191,722	231,642
Total	315,751	377,899	406,016	379,907

*In former years the crude ore as it came from the mine was entered in the *Statistique*, but of late years the poor ore which is concentrated appears in the tables only for the weight of the concentration.

To complete the foregoing statement of the products of the mining industry there should be added the products of quarries, concerning which accurate statistical data are not readily obtainable. They furnish building materials, hard stones, marbles, jasper, agate, slates, clays, phosphates, etc., which in the aggregate form a very important part of the mineral resources of the country.

The following table will give a sufficient idea of the foreign trade in ores: Foreign trade in ores.

Names of minerals.	1873.		1874.		1875.	
	Importation.	Exportation.	Importation.	Exportation.	Importation.	Exportation.
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
Lead ores	12,086	2,512	12,631	2,848	12,495	3,595
Copper ores	4,591	1,058	7,349	1,256	6,462	1,746
Zinc ores	25,370	3,250	23,720	1,748	25,219	2,786
Tin ores	.....	.....	428	.....	.....	.....
Manganese	24,498	1,651	26,014	686	17,440	1,362
Antimony	29	1	27	96	37	134
Iron pyrites	14,416	14,697	11,785	9,893	25,755	13,770
Sulphur	47,420	459	46,203	114	38,916	58
Graphite	975	51	934	78	978	55
Other ores	4,298	449	4,226	924	2,675	40
	Kilos.	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*
Ores of gold and platinum	32	.....	493	.....	1,910	.....
Ores of silver	4,546	.....	123,119	104,259	121,356	56,259

Statistics of laborers and wages.

In 1872 the laboring population employed in the mining industry amounted to about 320,000 men, of which number 134,173 were employed in the mines and peat works, 19,820 in underground quarries, 78,319 in open quarries, and 86,503 in metallurgical establishments. The following table presents some interesting data concerning wages and value of the products of labor in mines of different nature:

	Mines of—	1868.	1872.
Mean of wages paid annually to laborers in mines of....	Mineral fuel	$152 40	$196 00
	Peat	14 40	13 00
	Iron	111 50	149 40
	Other metals	113 40	117 40
Value annually produced per laborer in mines of.....	Mineral fuel	329 00	478 00
	Peat	25 60	26 60
	Iron	241 00	304 00
	Other metals	253 00	256 00
		Tonnes.	*Tonnes.*
Average annual production in tonnes of material per laborer in mines of.....	Mineral fuel	146.50	172.50
	Peat	12.80	12.05
	Iron	275.00	320.00
	Manganese	24.90	22.60
	Iron pyrites	108.00	126.00
	Copper pyrites	.....	162.50
	Argentiferous galena	31.06	24.06

In the above table the franc is reckoned at 20 cents United States currency. The tonne is 1,000 kilos=2,205 pounds.

Number, extent, and equipment of mines: 1868–1872.

A general idea of the condition of the mining industry of France is expressed by the following tabular statement, showing the number, extent, and equipments of mines in the years named below:

Mines of—		1868.	1872.
Mineral fuel	Number of mines	322	310
	Greatest depth ..... feet	2,066	2,093
	Steam-engines ..... Number	750	873
	Steam-engines ..... Horse-power	28,979	40,324
	Laborers employed	78,357	91,899
	Total production ..... tonnes	10,709,658	15,802,514
Peat	Number of exploitations	1,655	.....
	Laborers employed	30,518	26,893
	Total production ..... tonnes	421,342	324,697
Iron	Number of mines	92	81
	Number of quarries	814	282
	Steam-engines ..... Number	53	47
	Steam-engines ..... Horse-power	787	755
	Laborers employed	14,545	9,605
	Total production ..... tonnes	3,277,895	2,781,790
Other metals	Number of mines	59	51
	Greatest depth ..... feet	.....	804
	Laborers employed	4,572	4,029
	Total production ..... tonnes	210,819	232,296
Bituminous schists, bitumen, and sulphur.	Number of mines	25	26
	Laborers employed	.....	714
	Total production ..... tonnes	147,387	214,293
Rock-salt	Number of mines	13	16
	Greatest depth ..... feet	571	869
	Steam-engines ..... Number	32	35
	Steam-engines ..... Horse-power	338	492
	Hydraulic engines ..... Number	3	13
	Hydraulic engines ..... Horse-power	14	147
	Laborers employed	999	1,088
	Total production ..... tonnes	168,364	191,720

FRANCE.

It is not practicable to bring these tables up to date, for the form in which the statistics are published has been slightly changed; nor is this altogether to be regretted, since the data are evidently, if accurate, very incomplete.

Incompleteness of the data.

Laborers working in the peat-bogs, for example, certainly do not work the whole year through for thirteen dollars, and, if not, the corresponding data as to the number employed give no idea as to the amount of work done.

Fluctuations in wages and production per man.

The price of labor has risen since 1872. In 1875 the mean wages paid colliers was $211.65. The production per man in the coal pits has notwithstanding diminished. In 1875 it was 156 tonnes, against, 172.5 in 1872. This falling off is possibly due to the increased depth of the mines, but the difference is very large to be accounted for in this way.

Number and power of steam-engines in French mines: 1875.

Engineers will be able to gauge the extent of the mining industries of France in 1875 by a glance at the following table of the number and power of the steam-engines in use in that year:

Character of the mines.	Number of engines.	Equivalent in horse-power.
Coal or other fuel	1,023	48,962
Iron	53	976
Other metals	101	1,893
Total	1,177	51,581

Anzin Coal Mining Co.

The Anzin Coal Mining Company.

The Coal Mining Company of Anzin, as has been mentioned, is the largest in France. Its property covers 28,054 hectares, or about 108 square miles, and it produces annually above 2,000,000 tonnes of coal, employing 15,000 men, 12,000 below ground and 3,000 on the surface. If the facilities for drainage were good, from 5,000,000 to 6,000,000 of tonnes might be produced.

Extent and production.

Excellent exhibit: statistical and geological.

The exhibit of this company was particularly complete and instructive. Not only was very full statistical information furnished, but geological specimens illustrating the deposits were to be seen, as well as samples of coal and of artificial fuel, the tools employed, and, above all, a magnificent model of a portion of the coal-seam, with the underground and surface works accurately carried out to a scale of one-tenth. This model was as large as a small house. A passage led into the lower part of the structure, where the folding and faulting of the coal-seams and their relations to the overlying and underlying strata were admirably exhibited. The passage also led to a representation of the

Model of mine and mode of exploitation.

underground working, where were seen the division of the ground on the panel-work plan, the method of breasting the coal, the transportation of the cars by the tail-rope and endless-chain systems, and the hoisting through the shafts, in complete detail. The safety apparatus is that of Cousin, mentioned elsewhere. Ascending a stairway one reached a model of the surface works, including the buildings, engines, coal-screens, etc. In short, from the excellent disposition and execution of the model, the mines could be studied almost as well, and much more easily, than on the ground.

Coal Mining Co. of Anzin.

Model of the mines and works.

The Anzin Company washes its own coals, and manufactures coke and artificial fuel. This latter branch is one of great importance, the product being no less than 150,000 tonnes per year. For the purpose of sustaining it, the company has been obliged to establish a tar distillery, the liquid products of which are rectified and sold. The company owns 845 coking furnaces and manufactures 300,000 tonnes of coke a year.

Coal washing: coke and artificial fuel.

The usual arrangements for the material and intellectual welfare of the workmen and their families are provided on a liberal scale by the company.

Products of the French smelting works.

Smelting works.

To supplement the foregoing tables, information is given below concerning the yield of the French metallurgical industries. In this connection it is important to observe, what has already been noted, that French works draw a very large portion of their ores and crude metal from abroad.

Iron and steel produced in France.

Iron and steel produced in France.

Years.	Pig-iron.	Bar-iron.	Steel.
1819	112,500	74,200	.....
1826	.....	.....	4,915
1830	266,362	138,469	.....
1840	347,774	227,379	9,268
1850	461,653	246,196	10,981
1860	898,353	532,212	29,849
1870	1,178,114	830,786	94,387
1876*	1,395,657	870,312	230,829

* These data differ somewhat from those given in the "*Annuaire des Mines, d'après le service des mines.*"

Other metals produced in France.

Production of other metals than iron in France.

Metals.	1863.	1867.	1872.	1876.
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*
Copper and brass	14,762	18,016	21,455	25,085
Lead and litharge	23,652	27,761	21,486	27,163
Zinc, crude	1,175	3,485	8,245	.....
Nickel, crude	.....	.....	877	12,783
Aluminium, crude	1	1.7	1.8	.....
	Kilos.	*Kilos.*	*Kilos.*	*Kilos.*
Silver, fine	44,409	41,080	34,454	48,914
Gold, fine	500	737	410	850

Giant powder.

Giant-powder.

It is familiar to every one that the use of dynamite or giant-powder has increased enormously during the last years, in consequence of its greater explosive power, which may be estimated at from four to five times that of ordinary black powder; indeed, according to experiments made by order of the Prussian Government, the relation is as 1 to 6.7. Exact data as to the quantity of dynamite used are not accessible, but from 1875 to 1878 the factories of Nobel & Co., in Germany and Austria, alone manufactured 2,667 tons a year of this explosive, which is equivalent to about 10,000 tons of black powder per annum, which is not far from the amount of the latter yearly produced in England.

Relative explosive power of dynamite and gunpowder.

Production in Nobel & Co.'s factories in Germany and Austria.

Relative danger of nitro-glycerine and gunpowder works.

The preparation of nitro-glycerine explosives has been popularly supposed to be excessively dangerous. Figures, however, would seem to show that this is a mistake, at least when the operations are conducted with skill and care. There were only two explosions involving loss of life in the German and Austrian dynamite factories above mentioned, against twenty-four in England in the saltpeter-powder factories during an equal period. A dozen years or more of the use of dynamite have also shown that when made with even moderate care spontaneous decomposition and ignition do not take place, at least within four or five years after the material has been prepared. Another point upon which some misapprehension has existed is the behavior of frozen nitro-glycerine. It has been supposed that in the solid state nitro-glycerine and the explosives of which it is the base were much more dangerous and more easily fired. It appears to be true that cutting frozen nitro-glycerine with an iron tool may induce an explosion; it is said, however, that an explosion may even more readily be produced by similar means at a temperature exceeding the melting point of nitro-glycerine (7 or 8 degrees C.). In experiments made by artillery officers in Austria it turned out that fluid nitro-glyce-

As to spontaneous decomposition and ignition.

Behavior of frozen nitro-glycerine.

rine placed upon an iron plate has exploded by the impact of a rifle-ball at a distance of a thousand paces, while when frozen the distance had to be diminished to sixty paces in order to produce the same effect. It is also known that much stronger percussion caps have to be used in firing cartridges of frozen dynamite than in those where the explosive is in its normal pasty condition.

Behavior of frozen nitro-glycerine.

Besides samples of the ordinary preparations of nitro-glycerine, there was exhibited at Paris a new explosive invented by Mr. Nobel, and called *dynamite-gum* or *explosive-gum*. This is a mixture of collodion with nitro glycerine containing from 93 to 94 per cent. of the explosive compound. The two substances are mixed in such a manner that the product forms a gelatinous solid. In this new shape the nitro-glycerine exhibits somewhat different properties from those of the well-known preparations. When not confined—exploded, for example, on a piece of boiler plate—the dynamite-gum produces less effect than No. 1 giant-powder; on the other hand, when confined—as, for instance, in a drill-hole—the effect is 50 per cent. greater. The new explosive is, furthermore, vastly less sensible to shocks than other similar mixtures. A chassepot ball, striking the gum at a range of only 25 meters, failed to produce an explosion. It is consequently applicable to the filling of shells and to other military uses. Furthermore, water has no effect upon this substance. As to the permanency of the compound, the invention is too new to speak with absolute certainty; but cartridges kept for over a year in the air and under water show no sign of any change.

Dynamite-gum.

Its nature.

Behavior.

Less sensible to shocks.

Water resisting quality.

In a private letter the general manager of the *Société Générale pour la Fabrication de la Dynamite* says: The comparative tests which have been made on blocks of lead shown in our exhibit gave the following relations between the various explosives by volume. These relations may be regarded as those of the strength of the powders:

Military or mining powder	1
Dynamite No. 3	5
Dynamite No. 1	7.5
Dynamite No. 0 (cellulose base)	8.5
Dynamite-gum	10

Explosive power of respective powders, etc.

Safety apparatus.

Safety apparatus.

There were various safety apparatus exhibited at Paris, for the most part modifications of devices already familiar to mining men. M. Cousin's apparatus, invented a couple of years before the Exhibition, however, possesses some

Cousin.

FRANCE.

novel features. The clutch, instead of acting on the guides in case of accident, clasps a rope extending from the top to the bottom of the shaft. The lower end of this safety rope is fixed, but the upper end passes over pulleys, and is attached to a string of graduated weights, the upper one of which is the lightest. Consequently, when the safety clutch seizes the rope the arrest of the cage is not instantaneous; the safety rope is drawn down until, one weight after another being raised from the ground, the cage and its load are counterbalanced. This is an ingenious construction, and no doubt insures a gradual arrest of the motion of the cage, and prevents the destruction of guides. Whether American mining men will agree with the managers of some of the most prominent French mines, that the difficulties experienced with the more usual constructions are sufficient to warrant the complication involved by M. Cousin's plan, seems questionable.

Cousin's safety apparatus for elevators.

Description.

Somewhat complicated.

Safety apparatus providing against overwinding are becoming general in France. The fundamental idea is commonly to detach the cage automatically from the hoisting rope when it approaches the sheave dangerously. The attachment between hoisting rope and cage is so constructed that on striking a beam, passing through a ring, or, probably best of all, upon entering a hollow truncated cast-steel cone, the cage is detached. Its fall is then prevented by the action of the same apparatus upon which dependence is placed in case of the breakage of the hoisting rope. Provisions against overwinding should be more common in America than they are, even in our most important mining districts, and miners will readily recall frightful accidents arising from the lack of this precaution.

Anti-overwinding apparatus.

Description of its action.

Special regulations looking to the safety of the miners exist and are strictly enforced in France, as in all the great European countries. The number of accidents however is large, nearly two per cent. of the men being killed or wounded each year. More exactly, in the year 1875, which was not an exceptional one, 2.06 men per 1,000 employed in mining were reported as killed, and 17.73 per 1,000 as wounded. The coal-mining interests of France so greatly exceed the rest, that one might suppose the accidents mainly ascribable to the peculiar dangers met in the extraction of coal. Such, however, does not seem to be the case. The injuries arising from explosions of fire-damp and asphyxia amount to only 8 in 10,000 coal miners. A large majority of the accidents, especially of the fatal ones, in all classes of mines. are caused by the caving in of ground.

Annual percentage of killed and wounded by accidents.

Injuries from fire-damp less frequent than those from caving.

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The advances in the art of mining in France during the last ten years present no especial peculiarities. Steel cables have been introduced instead of iron to a very great extent; wooden and iron guides have replaced ropes used for the same purpose; the lowering and hoisting of miners on the cage, instead of the use of ladders, has become prevalent; rotary pumping engines have been introduced; safety lamps have been improved, but electric illumination has made little progress; ore-dressing and coal-washing have been greatly developed; and the manufacture of artificial fuel has become a very large business. In this last branch of industry pitch has been almost altogether substituted for tar, giving the advantages of lumps, which are more solid, and burn with less smell and less smoke. An addition has been made to the metallurgy of lead and silver by the introduction of the *Luce and Rosan* process, which is a Pattinson process, in which the stirring is effected by a jet of steam. By this process the complicated mechanism necessary in what is called the mechanical steam-pattinsonizing is avoided; the steam assists in the oxidation of impurities, and the concentration of the silver can be carried somewhat further than by the old method of manipulation. This process has been introduced into America (at Eureka) and into England.

Improvements in machinery of French mines.

Artificial fuel.

Luce & Rosan adaptation of the Pattinson lead-silver process.

Some general notes on models.

Models of mines and works.

One of the most noteworthy exhibits of this kind was the model in wire composed by *La Compagnie des Fonderies et Forges de Terre Noire, Lavoulte, et Bességes*, presenting in relief and at one view the form and features of the surface and the subterranean works of the mines at their proper relative depths beneath the surface. The subject of this plan comprised a superficial area about 3 miles long by 2 miles wide, perhaps a little more or less, beneath which were represented a portion of the underground works of the collieries and iron mines belonging to the company above ground.

La Compagnie des Fonderies et Forges de Terre Noire, etc.

Description of model.

This method consists in producing the form of the surface in equidistant contour lines represented by wires of sufficient strength, the contour in this instance being taken at intervals of five meters in vertical distance, and the horizontal wires being held in their relative position by other wires joining them transversely in such manner as to form a net-work presenting the relief of the surface.

Mode of development of plan.

This model was constructed by first preparing a map of the surface, on which the contour wires were carefully drawn.

Preparatory map.

FRANCE.

Each of these contours was then reproduced in brass wire. In order to place these contour wires in their proper relative position a series of profiles in wood was employed, formed of thin boards set up vertically and parallel to each other, each cut on its upper edge so as to form the profile of that part of the surface of which it represented a section. The contour curves in wire were placed upon and supported by the system of profiles, and after being adjusted precisely to their proper relative position were joined together by other smaller wires, so placed as to bind the net-work firmly, and at the same time to represent other features of the surface, such as the crests of the ridges, the beds of the ravines, the boundaries of properties, the lines of roads, the courses of streams, etc.

Model of Terre-Noire mines and works.

Mode of construction.

Upon this net-work it was then easy to place the representation on the desired scale ($\frac{1}{1000}$, or 83⅓ feet to the inch) of the principal buildings and works on the surface, removing finally the wooden profiles from underneath, and substituting for that means of support a sufficient quantity of small uprights of the desired length, and at convenient points.

The surface works,

The underground works of the mines were shown in similar manner. The various drifts, tunnels, and cross-cuts were represented by horizontal wires, each having the form required to correspond to the course and length of the work represented by it. These horizontal wires being placed in proper relative position beneath the surface net, were connected with other wires corresponding to the shafts, inclines, winzes, etc., and other accessory works of the mine, the whole being also supported from below by uprights fixed at convenient points. Moreover, the surface wires and those of the underground works were made to show the main features of the geological formation, by coloring them with different tints indicating the various rocks exposed on the surface or traversed by the mining works below ground.

and underground workings.

Colors to show geological formation.

The general effect of this method of representation is exceedingly good. The form of the surface, its nature expressed by color, and the relative position of all the objects shown upon it, were brought out in bold relief, while the spaces between the wires afforded a clear view of all the works lying beneath.

Excellent effect.

There were also various interesting models exhibited in plaster and in glass. Some of the plaster models were left in steps or terraces, the edges of which represented the contour lines. The glass models were made up of sheets set at regular distances. On each plate was drawn in trans-

Models in plaster and glass.

parent color a vertical or horizontal section of the ground corresponding to the scale of the model.

Algeria.

Statistics of mines.

Sixteen mines were being worked in Algeria in 1876, besides various prospects. In 1876 3,618 workmen were employed in making excavations and in extraction of ore. The following table gives the situation and production of those mines yielding over 5,000 tons in the year 1876:

Algerian mines in 1876.

Situation and production of mines.

Situation of the mine.	Nature of the ore.	Number of mines.	Production in tonnes.
DEPARTMENT OF ALGER.			
Soumah	Iron	85	11,936
Gourayas	Iron and copper	82	7,500
Zaccar	Iron	190	40,000
Qued Messelmoun	Iron	222	12,000
DEPARTMENT OF ORAN.			
Beni-Saf	Iron	310	50,000
Djebel Haronaria	Iron	220	14,000
DEPARTMENT OF CONSTANTINE.			
Kef-Oum-Theboul	Lead	387	12,162
Kharizar	Iron	167	21,636
Aïn-Morkha	Iron	1,471	368,446
Iron-ore mines		2,830	568,320
Other mines		788	17,412
		3,618	585,732

Steam-engines employed.

In 1875 the iron mines employed eighteen steam-engines, giving altogether 349 horse-power; the other mines, four engines, amounting to 60 horse-power.

No blast furnaces in Algeria.

Algeria possesses no blast furnaces. The greater part of its ores goes to France. Next to France, England buys the largest portion of iron ores; then follows Belgium, and then the United States.

Importation and consumption of coal.

The importation and consumption of coal for Algeria is seen from the following:

Year.	Imported from—		Consumed.
	England.	France.	Total.
	Tonnes.	*Tonnes.*	*Tonnes.*
1873	64,390	9,950	74,340
1874	58,380	18,260	76,620
1875	59,450	12,400	71,850

FRANCE.

Algeria.

The quantity of ores exported from Algeria has been as follows, in tonnes of 2,205 pounds:

Export of ores.

Year.	Iron.	Copper.	Lead.	Total ore.*
1869	215,205	5	2,827	218,036
1870	169,429	65	3,497	172,991
1871	172,333	1	2,611	174,945
1872	391,190	111	3,514	394,814
1873	420,700	72	5,446	426,214
1874	460,273	493	3,050	463,815
1875	522,630	3,020	2,355	528,005
1876	456,812	6,372	1,615	464,799
Total	2,808,566	10,138	24,913	2,843,618

*The original is given in *quintals*, or tenths of tonnes; consequently, there is an *apparent* error in the last figures of some of these totals.

Effect upon Algerian ore production of the development of the Pyrenean mines.

Up to 1876 Algeria escaped the effects of the financial depression prevailing all over Europe. Spain had for some years been involved in civil war. The mines of Biscay were shut down, and African ores, to the exclusion of all others, supplied the steel works. But since that time two causes have modified the situation—the pacification of Spain on the one hand, and on the other development of the mines of the Eastern Pyrenees, which have been put in communication with the sea and with the French system of roads by the completion of the railway from Perpignan to Prades. This checked the Algerian production, but only momentarily. The high quality of her iron ores, better appreciated every day, inspires the Algerines with confident hopes.

Guiana.

Guiana.

Gold.

The exportation of gold since 1875 has been not far from 2,000 kilos per year, representing a value of 6,000,000 fr., say $1,250,000. These are the official figures, but they probably fall considerably below the truth.

New Caledonia.

New Caledonia.

Geological peculiarities.

The geological formations observed in New Caledonia are of a very complex nature; but, speaking in general terms, it is easy to distinguish three distinct geological regions. First, fragments of primitive and of crystalline rocks, which occupy the extreme northern end of the island; second, serpentine rocks of great depth, which form, as it were, the skeleton of the island; third, metamorphic beds and sedimentary rocks associated with melaphyres, which occupy the west side. In respect to the metallic wealth which they contain, each one of these regions presents a special interest. Gold and copper are found in veins traversing the primitive rocks at the north of the island, the

Gold and copper.

New Caledonia.

serpentines contain an abundance of iron, chromium, and nickel, and the sedimentary rocks at the west inclose coal seams.

Iron, chromium, nickel, coal.

It was at one time supposed that New Caledonia would equal Australia and New Zealand in its mineral resources, but these hopes have been for the most part disappointed. Some gold has been obtained, but the mines appear to have been abandoned, and it is said that in depth the metal is replaced by pyrites. The coal seams are inclined at a high angle, and, so far as worked, yield only poor fuel. It is doubtful whether they can ever be made to pay.

Gold and coal enterprises have not thriven.

Thus far the most important ores furnished by New Caledonia seem to have been those of nickel. As for the yield of the mines, no authoritative statement has been found.* The New Caledonian nickel industry, however, possesses considerable technical interest, because it is founded upon a new ore, which is treated in part by new processes. On this account the following notes, which have been taken mostly from a paper by M. Jules Garnier, read before the Society of Civil Engineers, will be read with interest. It will also not be amiss to call the attention of engineers to the possible discovery of deposits of the new nickel mineral.

Importance of the nickel ores.

Jules Garnier.

M. Jules Garnier was the discoverer of a new nickel ore in New Caledonia, which has since been named *garnierite*. This metal is a hydrated silicate of nickel and magnesia, and occurs in various forms in serpentine rocks. Its formula is $(MgO,NiO)\ SiO_2+nH_2O$.† It is accompanied by compounds of iron and chromium and cobalt mineral.

Garnierite.

Its nature and location.

As is well known, the methods of extracting nickel from such ores as have hitherto been treated consist in concentrating the nickel in a regulus or speiss, dissolving the compound sulphide in acids, precipitating the nickel as oxide, and reducing the precipitate with carbonaceous substances.

Process with the usual nickel ores.

As garnierite contains no sulphur or arsenic, the application of ordinary methods to it involves the addition of minerals containing those substances in sufficient quantities to take up the metal. This mode of treatment M. Garnier considers economical under some circumstances (for highly ferruginous ores of low nickel tenor), but under many conditions, and with a large proportion of the ores, it was very desirable to invent a process less indirect, since the sulphur

Addition of ingredients to Garnierite to render it amenable to old process.

* In 1876, 463 tonnes of nickel ore, regulus, etc., were imported into France. In 1877 the importation rose to 3,790 tonnes. The increase is probably due, at least in great part, to the New Caledonian mines.

† According to M. Garnier, Dana's formula differs slightly.

FRANCE.

New Caledonia.

and arsenic are added only to be again separated from the nickel.

Garnierite: an ore of nickel.

M. Garnier has made numerous experiments with a view to devising such a process. The direct application of acids to the ore is ineffectual, since iron and nickel are not separated thereby. Experiments were also made upon the fractional reduction of the ore. The reduction was undertaken at a low temperature, at which it was supposed that nickel might be reduced, while the iron, or the greater part of it, would remain in an oxidized condition. This also proved impracticable, in part on account of the highly divided condition of the reduced nickel.

New process.

Finally, M. Garnier made experiments, and this time successfully, in the direct reduction of the ores in such a manner as to produce a pig-iron containing large quantities of nickel—a metal which may be called *ferro-nickel*. This process is carried out in a cupola furnace of about four meters in height, with cold blast at low pressure. Under these conditions, and with the proper smelting mixture, only a portion of the iron is reduced; the remainder goes into the slags, unaccompanied by nickel, and of course greatly increases its fusibility. When, as is sometimes the case, the ore contains only a small amount of iron, an addition of some ferruginous mineral must be made. The following are analyses of some of the ferro-nickels produced from an ore containing about equal quantities of iron and nickel:

Ferro-nickel.

Analyses of ferro-nickels.

Iron	46.55	41.30	38.70
Nickel	50.91	54.25	59.09
Carbon	3.04	4.45	2.30

A complete analysis gave:

Nickel	60.90
Iron	33.35
Silicon	0.85
Carbon	3.90
	99.00

As might be expected, the double carbide of iron and nickel is more fusible than the carbide of either metal by itself.

Character of ferro-nickel.

Ferro-nickel possesses great malleability, is easily worked under the file, takes a high polish, and shows a fine grained or foliating fracture. A large proportion of the nickel employed is used in the manufacture of German silver and other alloys of copper and nickel, bearing in trade a variety of names, such as argentan, alfenide, etc. German-silver founders prefer to purchase their nickel already alloyed with a certain amount of copper. To satisfy this demand

Its use.

Ferro-nickel-copper alloy.

the ferro-nickel is refined in a reverberatory furnace in the presence of copper, which, perhaps, also tends to preserve the nickel from oxidation. The refining of the ferro-nickel proceeds similarly to that of pig-iron, silicon oxidizing first of all, and the oxidation of the carbon soon manifesting itself by the boiling of the liquid mass and the ejection of carbonic oxide.

New Caledonia.

Ferro-nickel.

Refining.

Oxide of manganese and other substances of a similar tendency are added to hasten the oxidation, and, when necessary, silicious fluxes to take up the oxide of iron formed. The character of the residual alloy is determined from time to time by testing samples, and when the desired point is reached the metal is cast. If pure nickel instead of an alloy is desired, the process is similar, except in regard to the addition of copper.

Production of useful ferro-nickel alloys.

M. Garnier is now engaged in the attempt to produce technically useful alloys of iron and nickel. The somewhat discordant results which chemists and metallurgists have hitherto attained in experiments on this subject M. Garnier ascribes to the great sensitiveness of nickel to the presence of a variety of foreign substances. The study of the effect of impurities upon the metal will no doubt lead to a knowledge of the processes necessary to eliminate them.

III.

GREAT BRITAIN.

THE BRITISH EXHIBIT.

The period 1876–'78 not favorable for improvements in mining and metallurgy.

The period which has elapsed since the American Exhibition has not been a favorable one for the introduction of era-marking improvements in mining or metallurgical operations. The prolonged depression of business, the often short-sighted discontent of the laboring classes, and the pressure of foreign competition have forced those interested in such undertakings rather to endeavor by strict attention to economy in detail to keep already invested capital intact than to embark in new schemes. While, therefore, the British exhibit had much to offer which was of importance to professional engineers, there was little within the scope of this report to excite unprofessional attention. Many exhibits in Class 43 were, as it seemed, unnecessarily uninteresting. An array of samples of metal, grouped under the name of the manufacturers, showing fractures, or twisted to show toughness, is not indeed without its value; but it is certainly desirable that something more should be shown—samples of the metal in different stages of preparation and manufacture, models and drawings of apparatus, and the like. Exhibitors interrogated on this point sometimes answer: "We come to show our wares, not to teach others how to compete with us." But an international exhibition is not simply a gigantic advertising establishment; and even from the merely commercial point of view greater liberality in this direction is desirable than was shown by English exhibitors. It would be a strange mine that could show no fine samples of ore, a remarkable metal works which was unable to produce some bars it was not ashamed to exhibit. But those who have orders to give desire something more than this. They want evidences that they can depend on receiving uniformly good value. More ample exhibits tend strongly in this direction. Nor is the reputation of any establishment so high that it cannot be raised. To go outside of the range of this report for an illustration, the Creusot steel works has long enjoyed a high reputation; its exhibit in Paris was hardly characterized by novelty, but the effect of the admirable workmanship shown, combined with that of the models and drawings of apparatus,

Good products exhibited but the means withheld.

Nature and value of the reputation obtained.

Creusot steel works.

mills, dwellings for workmen, schools, etc., was such as probably to raise the works in the estimation of every visitor to its display, which was as crowded as the fine arts department. The fear of assisting competitors, too, is quite illusory. The history of modern technology teaches nothing more certainly than that the interchange of information is a mutual benefit. Mr. Bell is not less successful as an iron-master because, at the cost of immense labor and expense, he has taught the world so much about iron-smelting; and he would be the first to acknowledge the assistance he has received from others.

Creusot steel works.

I. Lowthian Bell.

In view of the absence of novelties of such a character that their description does not seem more in place in a technical journal than in a government report, it appears to me that the purposes of this publication, so far as Great Britain is concerned, will best be fulfilled by presenting a sketch of the recent growth and present condition of the mineral industry of that country. Information on this subject is constantly published, but commonly in so fragmentary a form that few of those most interested have leisure to piece the scraps into any consistent shape, important though it certainly is for each man engaged in mining or metal working to acquaint himself with the dangers to which the industry has been exposed, the tendencies it has exhibited, and, as far as may be, with the probabilities it offers. The following pages make no pretense of offering more than a sketch of the subject, although the labor of producing them is scarcely measured by their number.

What the author proposes to himself in the report on Great Britain.

Statistical review of the mineral industry of the United Kingdom for the years 1860, 1865, 1870, *and each year since.*

Statistical review of mineral industry of Great Britain.

One of the most important of the questions which are suggested by an international exhibition is: "Where do the ores, metals, and coal come from, and where do they go to?" An answer to this question, so far as the United Kingdom is concerned, goes very far towards forming a reply to the inquiry in its most general form, and cannot fail to be of interest and value to those who have to do with the products of mineral industries, whether as producers, consumers, or traders. Mining and metallurgical industries are, like others, very sensitive to disturbances arising from temporary causes, and a statement of their condition at any one period of time may consequently prove misleading. A systematic statement for a series of years, on the other hand, will exhibit the effects of temporary conditions, without obscuring the tendencies of the time, and assist the

As to the source and destination of the mineral products.

GREAT BRITAIN.

judgment in estimating the probabilities for the future. In the following pages I have endeavored to give, in the most condensed form, a review of the mining industry and commerce of Great Britain for the years 1860, 1865, 1870, and each year since, drawing the material for my data mainly from the yearly memoirs of Mr. R. Hunt, entitled "Mineral Statistics of the United Kingdom," and from "The Economist."

R. Hunt, "Mineral Statistics"; "Economist".

The market price of commodities regulates both the consumption and the production, for the price determines the conditions under which profit is possible, either to the consumer or the producer. No discussion of the mineral industry is, therefore, of much value in which this all-important factor is lost sight of. England, moreover, is the great metal market of the world, and English prices of metals control those obtainable at all commercial centers. The prices in London are consequently of great general importance, and are given for the series of years under discussion in Table I. A change in prices indicates, of course, a change in the relations of supply and demand, but no invariable inference is to be drawn from it as to the prosperity of the industry productively concerned. The price of a metal may fall in consequence of improvements in processes, such as followed the inventions of Bessemer and Siemens in steel making. Steel used to cost in England from $200 to $300 per ton, according to quality, when nearly all of this metal was produced by the blister-steel process, followed by remelting in crucibles; but steel rails were sold in November, 1878, at less than £7 ($34) per ton, delivered. Discoveries of new sources of supply, such as the Australian tin fields, may also bring down the price. The market, however, may also decline in consequence of disturbances in consumption, and a decrease of general prosperity, as has lately been the case. On the other hand, a rise in price may originate in a diminishing supply, as has been the case at times with tin and graphite, or in new applications (nickel plating), or in a sudden increase of consumption, based rather upon hope than upon that normal development of civilization with which the mining industry might keep pace. Iron of an ordinary quality is the metal most affected by the inflation or depression of speculative enterprise, because it enters more largely than other metals into the construction of railways, steamships, and the like. Cleveland pig iron at the works was worth, in 1871, £2 9*s.* 6*d.* ($12.03). In February, 1873, it rose to £6 7*s.* 6*d.* ($31). At the close of the year 1877 it

England the great metal market of the world.

Table I (page 210).

London prices of metals.

Causes of fluctuations in prices:

Cheaper processes.

New sources of supply.

Disturbances in consumption and general prosperity.

Diminishing supply.

New applications.

Ordinary iron the most fluctuating in price.

was worth only £2 4*s.* 6*d.* ($10.81), and it has recently been quoted at considerably below £2. Lead, in the mean time, has varied less than 30 per cent. of its lowest value.

The *tendency* of the prices of metals and minerals it is scarcely possible to discuss from a general point of view with profit, because the price is dependent upon so many factors; among others, the prosperity of one branch of mineral industry, viz, gold mining. The more largely the cost of manipulation enters into the value of a metal, the greater will be the downward tendency of the price, because "improved" processes means "cheaper" processes. Contrast with the variation in the price of steel mentioned above that of coal, which was cheaper in 1860 than in 1878, the increased depth of the pits and the higher wages having more than offset the improvements in coal-cutting machinery, etc. It cannot be doubted that in the case of copper, too, the development of the extraction of metal from "burnt pyrites" has had a considerable effect upon the price. The fluctuations in the price of silver have been voluminously discussed of late. The broad facts of the case seem to be that, in view of the immense production, it became manifestly impossible to maintain a definite relation of value between the precious metals; that thereupon gold was adopted as a standard by Germany and the United States, and the coinage of silver limited by the Latin Union. The abandonment in so great a measure of the principal use of silver, together with new discoveries, depressed the market violently, and would have done so still more had not the absorption of silver in the East increased. It is significant of the fact that silver has depreciated instead of gold appreciating, as some have maintained, that the East has absorbed silver in direct ratio to the depreciation, as might have been the case with any other commodity. Silver, as is well known, is circulated in the East in great part not by count, but by weight and fineness, like other merchandise. While all the metals are at lower rates than in 1860, wages have not receded to old standards in Great Britain.

Causes of fluctuations in value of minerals.

Coal.

Copper.

Silver.

Uno-metallic standard.

Indian absorption of silver.

With cheaper metals wages have not receded to old standard.

Wages of average miners in Scotland.

"Economist," March 9, 1878.

Miners' wages in Scotland, 1858–1877.

	s.	*d.*
1858	3	0
1868	3	9
1873	8	6
1877	4	3

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This is in part attributable to the higher price of the necessaries of life,* brought from constantly increasing distances, and in part to the difficulty the workmen experience in returning to the more penurious habits of their predecesors.

Table I (page 216).
London prices of metals.

Table I shows the average price of common metals and of coal in England for the series of years under discussion, the same being obtained from the average price of each work. In Table II the same prices are converted into American money. In these tables the miner or metal merchant will read a record of technical improvements, discoveries of ores, political convulsions, legislative experiments, of wild hopes and desperate panic, such as could in no other way be set before him in the same space. Causes for some of the fluctuations have already been indicated, and reasons for others may appear later.

Table II (page 217).
London prices in American money.

Table III (page 218).
Production of minerals in Great Britain.

Table III exhibits the quantities of the several metals and minerals produced in Great Britain for each year. The amount of copper produced from British ores, it will be seen,

Decrease in copper.

is decidedly decreasing. Tin, while it has undergone somewhat violent fluctuations in quantity, maintains itself tol-

Tin, lead, and silver stationary.

erably, in spite of the great reduction in price since the opening of the Australian mines. The quantity of lead produced in the years 1860, 1872, and 1877 differs but little. Silver follows lead very closely, as would be expected, since the silver extracted in Great Britain from native ores is almost exclusively obtained from lead.

The same quantities of different metals correspond to very different quantities of ore; the relations, however, are so nearly constant that it would be scarcely worth while to give the variations from year to year. Mining men may, nevertheless, be interested in knowing approximately the relations prevailing at British mines.

Relation of quantities of metal to ore.

Metallic contents of British ores. †

In the year.	Tin in 100 ore.	Copper in 100 ore.	Zinc in 100 ore.	Iron in 100 ore.	Lead in 100 ore.	Silver ounces in 1 ton lead.
1860	64	6⅜	28	47½	71½	8.68
1865	64	6⅜	25	48½	74⅜	10.78
1870	67	7	29	41	74⅜	10.69
1875	68⅜	7	28	38½	73⅜	8.49

* From 1845–'50 (6 years), wheat averaged 53*s.* a quarter, and beef of inferior quality was 4¼ to 4½*d.* per lb. In 1877 wheat was 57*s.*, and beef 5½ to 6¼*d.* *Ibid.*

† "Mineral Statistics," in part by calculation.

The rise in the percentage of metal in the "black tin" is no doubt due to increased care in the concentration so important with tin-stone. The zinc ore is almost exclusively "black jack." The diminished percentage of the iron ore is due to the increase of the proportion of British iron produced from the argillaceous carbonate of the Middlesborough district, which is low in grade.* In 1870 the North Riding of Yorkshire and the county Durham produced 26¾ per cent. of the total iron smelted in the United Kingdom. In 1875 this district produced nearly 32 per cent.

Causes of fluctuations in production of metal per given quantity of ore.

The Cleveland district.

Table III gives the metals produced from British ores exclusively, except in the case of iron, the figures for which include the pig produced from imported iron ores and "purple" ores, the residue of the pyrites-burning process. The quantity of imported iron ore will appear later. It amounts to less than 10 per cent. of the ore smelted. As the residue of the pyrites-burning after extraction of copper is used as an ore, both in the blast furnace and as "fettling," its composition may, perhaps, be more appropriately given here than later. Mr. F. Claudet found in "purple ore"—

Table III (page 218).

Production of native minerals plus imported iron ores.

Ferric oxide	96.00	=67 per cent. iron.
Lead (as sulphate)	.75	
Copper	.20	
Sulphur	.36	
Lime	.40	
Insoluble	2.11	
Phosphorus	none	
Soda	.10	
Total	99.92	

Composition of the purple ore; the result of pyrites burning.

The amount of iron produced in 1877 was within about 2 per cent. of the maximum production in 1872. Taken in connection with the table of prices, this fact affords a remarkable example of the extent to which the consumption of a metal can be stimulated by reduction in price. The year 1877 was assuredly not marked by enterprise, especially of the character which signalized the period of inflation, and yet nearly as much iron was consumed. It would be interesting to trace the details of this consumption were this the place for it. The production of zinc has increased greatly, and was scarcely checked by the panic of 1873. The same remark applies to salt and clay, especially the latter, which is about six times what it was in 1860 The quantity of pyrites mined has fallen off, but the decrease has been far

Comparison of production and prices of iron in 1872 and 1877.

Increased production of zinc, salt, and clay.

* Typical Cleveland iron stone contains 30 per cent. iron. See Bell, "Chemical Phenomena of Iron Smelting," p. 4.

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more than compensated by increased importation. The output of coal is astounding and highly indicative particularly when it is remembered that as improvements in the economy of fuel are constantly being made, the effective application of heat increases in a still greater ratio than the quantity of coal mined. According to Siemens, the annual improvement in the economy of fuel is equivalent to about 4 per cent. of the consumption. At present about 90 per cent. of the fuel is ineffectually consumed or wasted. The output of coal was diminished by the panic only for a single year, and in 1877 was about 7,600,000 tons greater than in 1873.

Immense output of coal.

Value of annual improvement in methods of economizing fuel.

Table IV (page 219).

Value of annual production of minerals in the United Kingdom.

Table IV, the value of the metals and minerals produced in the United Kingdom, is compiled from the yearly issues of the "Mineral Statistics." It is difficult to understand precisely how the items have been estimated. The value of any metal produced in any year would seem to be the quantity produced multiplied by the market price, and this view is borne out by many phrases in the "Mineral Statistics," and by the coincidence of the values there assigned, in a large proportion of cases, with the values arrived at by the method of calculation indicated. In a large number of cases, however, the values given differ from the product of the amount produced into the market price. Thus, while the value of the pig-iron produced in 1870 and 1871 is the same which results from multiplying the total product by the average market price of Cleveland pig at the Tyne or Tees for each of these years, the value of the pig-iron produced in 1873 corresponds to an average value per ton of only £2 15*s.*, which is £1 15*s.* below the lowest price paid in England for the cheapest iron in the district where it was produced in that year, and £3 below the average price of the same iron. In reply to an inquiry, Mr. Hunt writes: "I must beg you to observe that the mean price of Cleveland pig, which you quote, is from the 'Market Prices of Pig-Iron,' whereas, the value given in the introduction is an estimate of the value at the place of production, determined by private inquiry." But as the market prices are given "at works," or for the immediate neighborhood of the works, this explanation does not appear to me entirely satisfactory. It is impossible to suppose, in view of the phraseology and of many explanations in the "Mineral Statistics," that by "value" is meant "cost of production."*

Discrepancies between the results of the price and product and the statement of value of product.

* In the "Mineral Statistics" for 1870 Mr. Hunt says of the product of pig-iron, "This quantity, estimated at the mean average *price* at the place of production, would have a value of" so and so, which value is adopted in the general summary and corresponds to the market price

For the years 1872–1876, both inclusive, the value of pig-iron is uniformly estimated at a price below the average price of Cleveland pig. The values of the other metals and minerals correspond more closely with the market prices, though some not inconsiderable variations are observable. Thus, the value of the copper product for 1870 answers to a price per ton which is over £4 higher than the average price of best selected copper for that year. Of course the sums total are proportionately affected. That for 1870 contains a further error, and should, apparently, read £47,946,300. The price of coal is assumed at from 5*s.* to 7*s.* 6*d.*

Discrepancies in the tables.

Importation, exportation, and consumption of metals and minerals.

Importation, exportation, consumption of minerals and metals.

The United Kingdom neither supplies its own smelters with all the ores they require nor its native consumers with the needful quantity of every metal. Great Britain, moreover, exports enormous quantities of metals and minerals to other countries. The importation, exportation, and consumption of the products of mining industry are so closely connected that it seems best to discuss them together and metal by metal, reserving for the present the subject of the sources of supply and the distribution of the material handled. The necessary facts for this discussion are not, in all cases, directly obtainable. Estimates, however, where unavoidable, have been made on assumptions which will be explained as the cases arise, and which it is hoped will approve themselves to the judgment of the reader.

Mode of estimating consumption:

the sum of the production and importation minus the exportation.

The "consumption" of the metals and minerals is assumed, for the purposes of this paper, to be the amount retained in the country each year. The quantity retained is found by adding the importation to the production and subtracting the exportation. Of course it is not true that the amount retained each year is consumed in that year. A portion is, no doubt, usually stored, either for future use or exportation. For a series of years, however, it must be true that what is retained is consumed, and no other method of ascertaining the yearly consumption presents itself. The merely general correctness of the method will explain some of the fluctuations which will here and there be noticed. Doubtless many men of long experience in metallic commerce will recognize in some of these fluctuations periods when stock was allowed to accumulate on account of the

Reasons for suspecting the absolute accuracy.

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and value. The same remark and treatment is repeated in 1871. After this date I find no explanation of the method of arriving at the "value" given in the summary.

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unremunerative condition of the market, or when the state of affairs seemed to justify the policy of "holding for a rise." It is, however, foreign to the purposes of this paper to enter into any description of these exciting phases of the history of commerce. The metal imported into Great Britain is partly in metallic form and partly in the ore. In most cases the metallic contents of the imported ores is not published, but simply the quantity of ore, or its quantity and value. For the object of this discussion, however, it is essential to have an estimate of the quantity of metal contained in imported ore. Where the value of this ore is known I have supposed the relation of its metallic contents to its value to be the same as in the case of ores of British production. A rule-of-three calculation thus gives the desired datum. This is not strictly accurate, because in many cases an extra price is paid for the superior quality or purity of foreign ores. The influence of this disturbing factor must, however, be very small. In the comparatively few cases where only the weight of the imported ores is known, I have been obliged to assume their metallic contents to be near about, but a little higher, than that of British ores extracted in the same year. The importation of metal, the metallic contents of imported ore as estimated, the exportation, and the quantity retained in the country are given for each metal and mineral in Table V.

Imports in both the ore and metallic forms.

Mode of estimating value of metal in imported ores.

Importation, exportation, and consumption of minerals.

Table V (page 220).

Tin.—The world's production and consumption of tin have greatly increased within the period of time under discussion. The output of Billiton first amounted to 1,000 tons in 1865, and the Australian mines only became important in 1873. The consumption (for example, in the form of "tin" plate in the canning of food) has grown proportionately, notwithstanding the various devices, to which the great fluctuations in the price of this metal have given rise, for making a pound of tin cover a greater and greater surface of iron. Except in the years 1873 and 1874, after the opening of the mines in Australia and before the erection of smelting works there, the amount of tin ore imported into Great Britain has been small. In the mineral statistics for 1860 and 1865 only the quantity of imported ore is given. The metallic contents are taken at 64 and 65 per cent.; that of British ore being somewhat less. For the remaining years the contents are calculated from the value. The latter method would also lead to the conclusion that the ore contained about 65 per cent. of tin, so that there can be no considerable error in the estimate. The exportation of tin is very large for the years 1874, 1876, and 1877, larger than the pro-

Tin.

Billiton in 1865.

Australia, 1873.

Cheap tin-plate.

Large exportation.

duction from home resources. The consumption has exceeded the production ever since 1870, and Great Britain, which used to supply the world with tin, is now unable to meet her own demands, so much have these increased.

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Tin.

Increased consumption.

Copper.—As is well known, immense quantities both of metallic copper and of copper ores are imported into Great Britain. In 1860 the amount of this metal produced in the kingdom was slightly in excess of the metallic copper imported. With the exception of the year 1872, when the amount was exceptionally great, the importation increased steadily up to 1875, the home production decreasing the while to such a degree that in the last-mentioned year it was only slightly more than one-tenth of the importation. If the mines have retrograded, the smelting works have none the less flourished to such an extent that the metal produced from foreign ore treated in Great Britain in 1877 was twelve times as great in quantity as that extracted from native ores.* The larger part of the 50,000 tons, or so, thus separated is reduced from copper ores in Cornwall and at Swansea. Of late years, however, the extraction of copper from "burnt pyrites," containing about 4 per cent. of copper, by art processes of recent invention has assumed great dimensions and importance. Mr. Hunt estimates the amount of copper extracted in this manner in 1876 at 15,000 tons, and in 1877 at 17,000 tons, and states that the estimates in former years have been too low; a fact which accounts in part, but not wholly, for the enormous rise in the metallic contents of imported ore of late years according to the table. The "Mineral Statistics" records an increase of about 40,000 tons in the import of foreign ore for the year 1877, but, unfortunately, from unenumerated countries. The exportation of copper from Great Britain is very large and has been very steady since 1870, averaging about 54,000 tons. In compiling the data for the exportation and for the importation a difficulty has been encountered in the fact that, in several cases, the value only of manufactured copper is given in the "Mineral Statistics." The weight has been estimated from the value, on what appeared to be sufficient grounds, at seven-eighths of the value divided by the price of best-selected copper for the year in question. As the quantities are small, from a few tons to a few hundred tons, any slight error in this rule will affect the result but little. A small amount of ore and foreign regulus is

Copper.

Fluctuation in relation of native production and imported copper.

The new source of copper—from burnt pyrites.

Estimated amount.

Imports of ore.

Exportation of metal.

Mode of estimating weight given in the table.

* The metal reduced from foreign ores and regulus is given in the "Mineral Statistics" for each year except 1865. For that year I have estimated it by the rules presently to be mentioned.

GREAT BRITAIN. *Copper.*

sometimes exported from Great Britain. I have taken the metallic contents of such ore at 16⅔ per cent.* and that of the regulus at 25 per cent. The foreign regulus seems to have contained considerably less than 25 per cent. in the earlier portion of the series of years and considerably more towards its close. The quantity of copper retained for consumption in Great Britain is, according to the table, very irregular. The high price and active foreign demand in 1871 explains the small amount retained during that year, and the impetus given to manufacturing and short stocks account for the large figure for 1872. As residual quantities, the figures for consumption are most affected by the known inaccuracy of the returns of copper extracted from pyrites previous to 1876.

Causes of fluctuations in consumption, price, &c.

As to the amount of copper obtained from pyrites.

As Mr. Hunt himself draws attention to the erroneously small estimate of the amount of copper obtained from pyrites, perhaps it will not be amiss to calculate roughly what the true values probably were. According to Mr. J. A. Phillips (manager of one of the burnt-pyrites extraction works in Widnes), the copper contents of the burnt ore from imported pyrites is remarkably constant, and is about 4 per cent., which is also the percentage adopted by Mr. Hunt for 1876 and 1877. The following table shows the data in the matter and the difference in the copper product which would arise if the conjectural quantities were adopted. Pyrites, when roasted, leaves about 70 per cent. of "burnt ore," which (making an allowance for non-cupreous mineral) agrees well with the suggested corrections. In 1876 some pyrites must have been unreported, or a part of the mineral richer than usual.

About 4 per cent.

Statistics of copper extracted from burnt ore.

Copper extracted from burnt ore.

Years.	Returned consumption of burnt ore.	Estimate of copper in "Statistics."	Four per cent. of burnt ore.	Difference.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1870	200,000	7,500	8,000	500
1871	225,750	7,900	9,030	1,130
1872	253,529	8,500	10,141	1,641
1873	323,910	12,800	12,956	156
1874	†329,004	9,000	13,160	4,160
1875	†365,368	9,600	14,614	5,014
1876	379,269	15,000	15,170	170
1877	427,954	17,000	17,118	118

*Partial returns of foreign ores sold at Swansea in 1865.

†These are the values given under "Pyrites." Under "Copper," the "Mineral Statistics" gives, for 1874, 450,000 tons, and for 1875, 480,000 tons; but these quantities would be over 80 per cent. of the total import and home production of pyrites in these years, whereas pyrites loses 30 per cent. in the roasting process.

The metallic contents of imported ores and the consumption as given in the table would be altered as follows, by assuming the copper extracted from "burnt ore" to be 4 per cent. of the quantity of that substance returned as "consumed:"

Copper.

Revised table of metallic copper in imported ores on a basis of 4 per cent.

	1870.	1871.	1872.	1873.	1874.	1875.
Metallic contents of imported ore.	27,525	24,801	28,843	26,912	32,054	34,497
Consumption	12,418	7,676	24,851	12,276	17,199	28,880

The variations here are less abrupt than in Table V.

Lead.

Lead.—The home production of lead is both large and steady, and in 1860 was just about equal to the home demand. The quantity of metal imported was one-third of the home production in 1860, but both consumption and export trade have so increased that in 1877 half as much again was imported as was produced. The business of smelting foreign lead ores has grown in a still greater proportion, the metal extracted from them in 1860 being but a few hundred tons, while in 1877 it was close upon 10,000. So steady has the lead trade been, that, although the import of metallic lead was quickened in 1872, it has since risen to far higher figures. The irregularity observable in the importation of lead ore in the years 1871 and 1872 was caused by shipments from the United States, which sent 7,589 tons of ore to England in 1871 and 2,709 tons in 1872. For the other years under discussion the importation from this country has been quite insignificant. The export of lead in 1860 was very nearly the same as the import. It has about doubled since that time, but shows considerable irregularity, owing principally to fluctuations in the demand from America and China. The consumption, too, has doubled during the past eighteen years, and its growth was scarcely checked by the crisis of 1873. In collecting the data for the table it has been necessary to assume a certain percentage of metal in the lead ore in order to reduce the quantities to comparable terms. The percentage taken was 75 (pure galena contains 86.6 per cent.), which is about 1 per cent. above the average of British ores. The few tons of litharge and white lead which appear here and there in the statistics are taken together at 80 per cent. metal. For the years 1876 and 1877 the export of British lead only is reported by Mr. Hunt. In 1874 the export of foreign lead was about 5,000 tons, and in 1875 about 3,300 tons. For the sake of completing the table approximately, I have therefore added 3,000 tons to the export of British lead for each of the last years in the table.

Fluctuations in relation of home production and importation.

Exports and imports of lead, equal.

Increased consumption.

As to estimating percentages of metal in ore for the purposes of the table.

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Zinc.

Steady in price, production, and consumption.

Zinc.—Like lead, zinc has been comparatively steady in price, production, and consumption. In both cases this steadiness is probably attributable to the extent to which they enter into the indispensable construction of buildings and the manufacture of paint. Great Britain possesses but little zinc ore, and this little is almost exclusively zinc blende, or "black jack," the most inferior of zinc ores. Consequently the country has depended chiefly for the quantity of metal consumed on supplies from Germany, Belgium, and Holland, receiving some six times as much as it produces. Large quantities of foreign ore have also been smelted in Great Britain of late years, particularly since the importation of the carbonate from Sardinia began in 1867. The supply of foreign ores has latterly decreased. The exportation of zinc is small, about 7,000 tons, or slightly more than the production. The consumption has risen very steadily to treble what it was in 1860, and is nearly ten times the production. The metallic contents of the imported ore have been ascertained from its weight and value, on the supposition that these quantities bore the same relation to one another in the foreign as in the British ore.

Britain imports six times the quantity of home production.

Consumption trebled 1860–1875.

Iron.

Included in table V for sake of comparison.

Iron.—For the sake of comparison the data with reference to iron are also introduced. As the figures for the product of Great Britain include the pig reduced from imported ore, it is not necessary to consider separately the metal thus obtained. The imported ore probably contains about 66⅔ per cent. iron, and includes the "purple ore" from the burnt pyrites. Wrought-iron and steel are, of course, not taken into account in the production, because they are manufactured from pig-iron. In the exportation, on the other hand, both must be counted, as they cannot represent the same metal. The iron imported into England used to be exclusively of high quality and such as could not be made in the country, surbars (made from manganiferous ores with charcoal), Westphalian "spiegel," and perhaps some other. The reviews now complain that Belgium is sending the cheapest iron to England for building purposes, and that Westphalian steel works are underbidding English establishments in the home market.

Pyrites.

For sulphuric acid manufacture.

Pyrites.—The extraction of sulphur and sulphurous acid for the sulphuric acid manufacture from the minerals classed under this name is said to have been suggested only some 40 years ago. The business has assumed enormous proportions of late years, as will be seen from the table. The plan of extracting small quantities of copper from the residue

after expulsion of the 45 per cent. or so* of sulphur contained in the mineral seems to have been first carried into operation on a large scale in 1867. In that year 500 tons of copper is accredited to this source in the "Mineral Statistics." As has been already mentioned, the residue after the extraction of the copper is employed under the name of "purple ore" in iron-smelting. This is a proof of the perfection of the preceding processes, for, as is well known, sulphur and copper are fatal to the value of iron ore when present in more than exceedingly minute proportions. Indeed, the process may be considered as one of the most perfect in the arts, all the essential ingredients of the mineral being profitably extracted and thoroughly separated. Prof. Thomas Thomson, of Glasgow, a famous chemist in his day, is credited by Muspratt with the initiation of the manufacture of sulphuric acid from pyrites in 1835, when the King of Sicily placed a heavy duty upon exported sulphur. Henderson and Longmaid, English chemists, worked out the copper extraction process much later. The treatment of pyrites is, therefore, an achievement of modern science. Both as an instance of the relations existing between science and industry and as a matter of growing commercial importance, it may be interesting to dwell for a moment on the financial results of this process, results which ought to go some way towards vindicating the "practical" character of modern scientific teachings.

Pyrites.

Extraction of copper from the waste.

"Purple" ore.

Prof. T. Thomson.

Henderson & Longmaid.

Illustration of value of modern scientific teachings.

Results of the treatment of cupreous pyrites in 1877.

The pyrites industry.

Pyrites imported, 679,312 tons, yielding 45 per cent. sulphur, or 305,690 tons, equal to sulphuric acid (worth 1*d.* per lb., or £9½ per ton), 917,071 tons	£8,559,024
Copper extracted, 17,000 tons, worth at £74 12*s.* 6*d.* (price of tough cake)	1,268,625
Purple ore, smelted, 415,000 tons, containing 65 per cent. iron, or 260,750 tons pig, worth at £2 5*s.* 6*d.* (price Cleveland)	613,670
Total	10,441,319
	$50,144,810

This is a minimum estimate, for a large proportion of the small percentage of silver contained in the pyrites is extracted, as well as some of the gold, by M. Claudet's process.

Silver.—The data relating to the exportation, importation,

Silver.

*It has been stated under "Copper" that the burnt ore amounts to about 70 per cent. of the pyrites. This is not inconsistent with the loss of 45 per cent. of sulphur, because the sulphur is replaced by oxygen. A gross loss of 30 per cent. by weight answers to a loss of 48 per cent. of sulphur. A little sulphur remains in the burnt ore.

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Silver.

and consumption of silver are imperfect and unsatisfactory. The movements of this metal are so largely controlled by the exigencies of Eastern commerce and by the financial policy of the great commercial countries, that their discussion is only in a very subordinate degree an affair appertaining to the mineral industry. During certain years vastly more silver has been exported from Great Britain than has been imported. In other years enormous quantities have been retained in the country. The facts bearing upon this point have been elicited by the British and the American Silver Commissions. A single feature of the subject appears to me to have received less attention than it was entitled to, viz, the extent to which foreign argentiferous ores are treated in Great Britain. This point is not covered by the "Mineral Statistics," and I know of no source whence absolutely trustworthy data are to be obtained. In the absence of such, I have prepared a rough approximation, which may serve to give those interested at least some idea of the extent to which silver is separated in the United Kingdom.

The great eastern drain for silver.

Researches of the British and American Silver Commissions.

Besides the desilverization of argentiferous British lead, metallic silver is derived from the following sources: The treatment of silver ores entered at the custom-house as such; the desilverization of foreign lead sent to England largely for that purpose; copper ore and regulus and cupreous pyrites.

British source of metallic silver.

Considerable quantities of silver ore are annually sent to Britain, mainly to Swansea, and the declared value of these ores is regularly noted in the "Mineral Statistics." The number of tons is also given up to the year 1873. The silver contents of these ores are not, however, inferable from their gross weight and value, because a higher price per ounce is paid for the silver in high-grade ores than for that in poor ores. A comparison of the average price per ton with a price list would consequently lead to too high a valuation of the number of ounces of silver imported.* The error which would be incurred by such a procedure can be obviated by assuming a sufficiently high rate in calculating the contents from the value. Five pence per ounce would certainly be a small mean charge for the separation of silver from its ores.†

Foreign ores smelted in Britain.

Mode of estimating value of ores.

* The maximum price per ounce is subject to a deduction which is inversely proportional to the number of ounces per ton. Hence the mean *contents* of two lots correspond to a lower rate than is actually paid. Were this relation reversed it would pay to mix poor ores with rich ones, an absurd supposition.

† The average value of the imported silver ores for three of the years under discussion in which the tonnage is given is just £100.

This is about the difference between the value of standard silver and fine silver. In the table given below the amount of silver obtained from silver ores has been estimated by dividing the declared value of the silver ores imported during that year by the average price of standard silver (0.925 fine) for the same period.

Silver.

It may be assumed that all the lead imported into Great Britain is desilverized there, because, on account of the organization of industry and the abundance of fuel, the separation can be more economically effected there than, for instance, in Spain or Greece, the principal sources of supply. It is probably fair to assume that the imported lead contains at least 25 ounces of silver per ton.*

Silver in lead.

The cupreous pyrites treated in England contains a small quantity of silver per ton, which is at present recovered, at least in part, by Claudet's beautiful process. According to Mr. Phillips, ordinary pyrites yields in this way 0.65 ounces silver per ton. The process was, however, only introduced in 1870. It does not seem excessive to allow ½ ounce per ton since 1874 from this source.

Silver in cupreous pyrites.

Claudet.

The amount of silver derived from copper ores other than pyrites I have no means of estimating. Only certain copper ores are apt to contain silver, but such, either raw or in the form of regulus, would naturally be preferred for shipment. I will assume it at 12½ ounces per ton of copper produced.†

Silver from copper ores.

Estimate of silver produced in Great Britain from imported materials, in ounces.

Silver produced in Britain from imported materials.

Years.	From silver ores.	From lead.	From cupreous pyrites.	From other copper ores.	Total in round numbers.
1864	1,489,200	569,475	.....	171,438	2,230,000
1865	1,503,000	979,275	.....	299,025	2,780,000
1870	1,187,800	1,732,525	.....	337,813	3,260,000
1871	3,784,300	2,021,750	.....	295,888	6,100,000
1872	8,707,000	2,080,050	.....	271,275	11,010,000
1873	4,134,100	1,796,100	.....	334,450	6,260,000
1874	3,166,600	1,839,950	249,319	348,675	5,600,050
1875	2,300,300	2,227,725	268,778	368,538	5,170,000
1876	2,273,900	2,252,975	252,376	452,388	5,230,000
1877	2,463,200	2,602,700	339,656	669,775	6,080,000

*Italian lead averages 25 ounces, according to Phillips. Greek lead averages in the neighborhood of 20 ounces, according to Percy. Spanish lead, according to a circular of Luce and Rozan, 44 ounces. French lead is richer. English lead averages about 10 ounces.

†Cupreous pyrites contains 2.8 per cent. copper. If ½ ounce per ton pyrites is recovered, then 18 ounces of silver are obtained for each ton of copper derived from this source.

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The items are given in the table as they result from calculation, but are to be viewed, of course, only as, perhaps distant, approximations. It is, however, probably fair to say that the amount of silver produced in Great Britain from foreign ores has been, since 1870, excepting in 1872, from 5 to 7 millions of ounces yearly, or, say, from 6½ to 9 millions of dollars. Sir Hector Hay, in his testimony before the British Silver Commission, estimated this quantity at £1,000,000; Mr. E. Seyd at considerably less.

Estimated British production of silver.

Consumption of silver.

The consumption of silver in Great Britain was estimated at about the value of 5½ millions of dollars, but, it is said, without taking into consideration the quantity separated either from foreign or native material.

Coal.

Coal.—Rather more than one-tenth of the output of coal in Great Britain is exported, and this relation has been pretty constantly observed throughout the period under discussion. Both export and consumption were merely disturbed by the crisis of five years back, and were far greater in 1877 than in 1872–'73.

Export one-tenth of the output.

Mr. Hunt has gathered some exceedingly interesting data concerning the uses to which coal is put in Great Britain for the years 1871–'72–'73. The table for 1873 is here substantially reproduced. In a second table I have calculated the proportion of fuel consumed for various purposes from Mr. Hunt's table. It will be seen from these tables that the mining industry consumes almost half of the coal used in England for industrial purposes and 40 per cent. of the total amount burned.

The employment of coal.

The uses for which the coal raised in Great Britain was employed in 1873.

	Tons.
Tin smelting and refining	42,422
Copper smelting and refining	360,195
Lead and silver smelting and refining	179,540
Zinc smelting and refining	181,450
Iron smelting and refining	35,119,709
Mines and collieries	9,500,000
Total mining and metallurgy	45,383,316
Railways	3,790,000
Steam navigation	3,650,000
Steam power in factories	27,550,000
Water works	650,000
Gas manufacture	6,560,000
Pottery, bricks, lime, glass, etc	3,450,000
Chemical works and sundry	3,217,229
Household consumption	20,050,000
Exportation *	12,712,222
Total	127,012,767

* The quantity of coal exported in 1873 is given at a slightly lower figure in later numbers of the "Statistics."

Relative quantities of coal employed for various purposes in Great Britain in 1873. GREAT BRITAIN.

Relative quantities of coal employed for various purposes.

	Of the coal raised.	Of the coal not exported.	Of the coal industrially consumed.
	Per cent.	*Per cent.*	*Per cent.*
In mining and metallurgical industries	35.74	39.70	48.15
On railways	2.98	3.32	4.02
In steam navigation	2.87	3.19	3.88
For steam power in factories	21.69	24.10	29.23
For steam power at water works	.51	.57	.69
For manufacture of gas	5.17	5.74	6.96
In potteres, glass works, etc	2.72	3.02	3.66
In chemical factories and sundry	2.53	2.82	3.41
For household consumption	15.79	17.54	.....
Quantity exported	10.00	.....	.....
	100.00	100.00	100.00

Estimate of proportion of coal employed in mining and smelting.

What the relative proportions in other countries are it might be difficult to ascertain, but it is probably safe to say that fully one-third of all the coal raised is consumed in mining and smelting operations. The economy of fuel in iron-smelting has of late years made considerable advances under the stimulus of high prices of coal and low prices for iron. In 1870, Mr. Hunt ascertained the consumption of coal per ton of pig-iron to be three tons. In 1877 the consumption in the manufacture of pig had fallen to 2½ tons. The manner in which this economy has been effected, the more judicious dimensions selected for blast furnaces, the improved hot-blast stoves, and the general study into the science of iron-smelting under the efficient leadership of Mr. Bell will doubtless be discussed in the special report on iron and steel.

Sources of supply and destination of ores and metals.

Foreign sources of supply and points of destination of ores and metals handled in Great Britain.

England's worldwide commercial intercourse.

England carries on not only a larger but a much more extended trade in metals and ores than any other country. In 1877 foreign ores were imported at 62 ports in the United Kingdom, and it would be difficult to find a mining district in the world which does not send ore or metal to England, or a market at which no metal is received from the United Kingdom. An exhaustive discussion of this traffic would be scarcely possible under the most favorable circumstances, and no attempt will be made here to do more than give a few characteristic data and to point out a few salient features of the subject. The tables are especially recommended to those who feel any interest in the matter, as small infor-

Tables VI to XI, pages 221-225.

GREAT BRITAIN.

mation and a trifling amount of patience will serve to elicit many interesting facts concerning the development of human industry and the interdependence of human pursuits from them.

Tin.

Tin.—Little tin ore has been imported into England, except for a couple of years after the opening of the Australian tin mines. Chili and Peru send a small amount with some regularity, and Holland and the Straits now and then a ton. This ore is probably brought to Europe as ballast by trading vessels which have been cruising among the islands of the Malayan Archipelago. The Cape also sends a trifling amount from time to time. Even France, Spain, Portugal, and other countries have occasionally sent a few tons. The fact is that tin-stone, like cinnabar, is not a very rare mineral, though there are but few localities where it occurs in paying quantities. It may be a surprise to some to see that Australia sent tin-stone in relatively considerable quantities to England long before the mines which have grown so important were discovered. The contents of the ore recorded in the table may probably be taken at about 70 per cent. metallic tin.

Table VI (page 221).

Sources of tin ore.

Australia and Strait-settlements the principal sources of metallic tin.

The principal foreign sources of metallic tin are Australia and the Straits, tin from the Dutch Indies going principally to Continental markets. It is interesting to observe from the table how rapidly the Australians mastered the business of tin-smelting, the exports of ore having fallen within a couple of years of the great discoveries to a lower point than that at which they were before, and the amount of metal sent "home" having more than proportionately increased. The imports of tin from Australia are given as per parliamentary returns. In later volumes of the "Statistics," however, Mr. Hunt appears to adopt figures at first given as unofficial, and which are as follows:

Imports of Australian tin.

	Tons.
1872	150
1873	2,990
1874	5,800
1875	7,210

The imports from the Straits show a rapid increase. This tin appears to be smelted by natives and Chinese on the Malayan Peninsula, from stream tin, in rude hearths, but the writer has been unable to find any statement of the conditions. The principal consumers of tin are, as might have been expected, France, Germany, and the United States, and the consumption has grown enormously with the fall of price. Germany produces some tin for home consumption, and, of course, Dutch tin is consumed more or less in all countries.

Fall in price and great increase in consumption.

GREAT BRITAIN.

It will be observed that the table contains no data for 1876 and 1877, and the same will be found to be the case for several of the succeeding tables as well. For these years neither the "Mineral Statistics" nor the "Economist" gives sufficiently detailed accounts of the imports and exports to make the compilation of the data possible, a fact which I greatly regret.

Tin.

Copper.—By no means all of the sources of supply are given in the table, many other countries sending small lots of ore and metal; nor are the copper contents of cupreous pyrites taken into account. Chili, Australia, and the Cape of Good Hope are the principal countries from which Great Britain imports copper and its ores, and of these Chili is much the most important. It will be noticed with interest that both Australia and Chili are every year sending a greater proportion of metallic copper, and a smaller one of ore, indicating the advance of the metallurgical industries of those countries. The Cape, on the other hand, while sending far more ore to England than any other country except Chili, sends no metallic copper and only an insignificant quantity of regulus. The metallic contents of the ore and regulus are higher than formerly, apparently because most of the regulus now imported is concentrated at the mines. The average copper contents of ore and regulus together were 18 per cent. in 1873, in which year about one-third of the total importation was regulus, while in 1877, less than one-fourth of the total being regulus, the average copper contents were about 24 per cent.

Copper.

Table VII (page 222).

Sources of copper and copper ores.

Increase in Australian and Chilian imports of metallic copper.

Increased richness of the copper imports.

All the principal countries of Europe and British India are large consumers of copper from England, though several of them are large producers. The United States, on the other hand, has bought only insignificant amounts of this metal from England, except in the years of inflation, nor does this country send any noticeable quantity of ore or metal to England, although Lake Superior copper has the preference for telegraphic purposes.

Consumers of copper from England.

Lead.—Comparatively little lead ore is imported into England, and that chiefly from Italy, while Spain sends enormous and increasing quantities of the metal. Greece sent large amounts of metal for a time, but the import from that country fell off suddenly in 1874. Much the most important customer of the English lead merchants is China, which in 1877 took about as much as all the other principal countries together. France, Germany, Russia, and the United States are of course large producers of lead. The quantity bought by the United States has fluctuated greatly, though on the

Lead.

Table VIII (page 223).

Sources of lead and lead ore.

China the principal customer of England.

GREAT BRITAIN.

Lead.

whole it has declined since 1870, when it was nearly 13,000 tons. In 1875 we bought of England only 485 tons, but the importation had risen again in 1877 to nearly 3,000 tons. The figures for exportation are the corrected values given in the "Mineral Statistics" for years subsequent to those to which the numbers refer. I am inclined to the opinion that for the years 1876 and 1877 only the British lead is reported, although no statement to that effect is made. The exportation of foreign lead is small, being less than 10 per cent. of the whole in 1875. Russia in that year took the largest proportion of foreign lead, about one-eighth to seven-eighths of British production.

Zinc.

Zinc.—Large quantities of zinc ore of foreign production are smelted at Swansea. They come chiefly from Spain and Sardinia, especially the latter, and are mainly carbonate. The importation of zinc ore from Sardinia began in 1867, and was over 30,000 tons in 1870, but little more than half this quantity in 1875, and still smaller since, for in 1876 the total quantity of zinc ore imported fell short of 12,000 tons. In 1877 the total import rose again to over 19,000 tons. The imports of ore from other countries are insignificant. The metallic contents of the imported ore, as calculated from its value, are in the neighborhood of 40 per cent. Pure carbonate contains 52 per cent.*

Table IX (page 224).

Spanish and Sardinian ores.

Importations of Belgian and Silesian metallic zinc.

Belgium and Silesia are the two most important zinc-producing districts in Europe, and from them England imports the greatest quantity of crude and manufactured (mostly rolled) metal. England also imports much zinc from Holland, a country which produces none. I have failed to discover how this happens.

Great Britain exports insignificant quantities of zinc, except to its own possessions in India.

Iron.

Iron.—No sufficient data for ascertaining the distribution of iron exported from England have been found.

Pyrites.

Pyrites.—Spain, Portugal, and Norway furnish essentially all the pyrites imported into England. In the beginning of the period under discussion Portugal was the main source of supply, but the Spanish mines have been developed with great steadiness and rapidity, and in 1876 furnished more than four-fifths of the total supply.

Table X (page 224).

Coal.

Coal.—Excepting Belgium, all the principal countries of Europe are large consumers of British coal, France and

Table XI (page 225).

* The zinc contents of Sardinian ore probably fall a little short of 40 per cent., a higher price being paid for the superior quality of the ore. According to a statement of Mr. Vivian to Mr. J. A. Phillips, the Sardinian product averages about 33 per cent.

GREAT BRITAIN.

Coal.

Germany leading. The large amount taken by Chili is no doubt sent out, with manufactured goods, in ships which come home loaded with copper, etc. The coal sent to the United States is probably for gas-making purposes. The high prices of 1873 checked the exportation to most countries, but the general tendency is to a decided increase; Germany, however, has never since imported so much coal from England as in 1871, while France takes about half as much again as at that period. British India affords a large and constantly increasing market for English coal, notwithstanding the immense distance.

Destination of British export.

GREAT BRITAIN.

London prices of metals 1860–1877.

TABLE I.—*Average price of metals and coal per ton (except silver) in London.*

		1860.	1865.	1870.	1871.	1873.	1873.	1874.	1875.	1876.	1877.
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Pig-iron at works	Cleveland	2 14 11	2 9 6	2 9 6	2 9 6	5 4 6	5 15 0	3 15 6	3 0 0	2 13 0	2 5 6
	Scotch	2 14 0	2 19 0	3 19 3	3 2 3	5 10 0	6 10 0	4 19 0	3 4 0	2 18 6	2 14 4
	Welsh	3 16 0	4 15 0	4 0 0	4 6 7	6 12 0	6 10 0	5 7 6	4 4 11	4 2 6	3 17 6
Tin	English	126 3 1	96 15 0	127 8 6	137 10 0	153 15 0	133 7 0	108 8 0	80 2 0	79 10 2	73 3 6
	Banca	126 13 10	96 0 0	125 0 0	135 0 0	153 5 0	134 14 6	103 0 0	80 0 0	73 12 11	71 7 0
	Best selected	109 13 10	84 7 0	73 13 0	77 10 0	104 5 0	96 13 0	89 12 0	80 0 0	83 6 3	75 16 0
Copper	Tough cake	106 13 10	91 15 0	70 11 0	75 10 0	97 15 0	93 13 6	84 0 0	83 9 0	81 19 6	74 13 6
	English plg	93 6 3	80 3 0	68 13 0	73 4 0	90 0 0	88 6 0	82 2 0	82 9 4	81 18 10	80 11 3
Lead	English (W. B.)		21 6 0	19 12 6	19 17 6	21 14 0	24 7 8	23 3 6	23 6 6	23 1 9	21 7 0
Zinc, English		20 11 0	20 13 0	18 16 6	18 11 6	23 15 0	28 15 0	28 6 6	24 5 0	23 18 4	21 15 0
Silver (per ounce)		61¼d.	61½d.	60¾d.	60½d.	60¾d.	59¾d.	58¾d.	56¾d.	52¾d.	54¼d.
Coal	Cheapest	18 11	14 0	16 0	16 10	1 3 6	1 9 6	1 2 11	1 0 6	18 6	16 6
	Dearest	1 2 9	18 9	17 0	18 10	1 4 6	1 12 0	1 4 11	1 3 0	1 0 5	18 6

London prices of metals 1860–1877, in American money.

TABLE II.—*Average price of metals and coal per ton (except silver) in London.*

		1860.	1866.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
Pig-iron at works	Cleveland	$13 24	$13 03	$12 03	$12 03	$25 39	$27 95	$18 35	$14 55	$12 38	$11 05
	Scotch	13 12	14 24	14 40	15 11	26 73	31 71	24 06	15 55	14 09	13 20
	Welsh	13 47	23 21	19 44	21 04	32 08	31 71	26 12	20 03	20 05	18 33
Tin	English	661 71	470 21	619 23	668 25	743 87	648 08	620 83	457 20	336 41	355 68
	Banca	664 23	461 70	607 50	657 55	744 80	654 76	500 58	457 40	357 93	346 79
Copper	Best selected	553 10	438 54	553 08	576 65	506 66	466 07	435 46	457 40	404 33	368 39
	Tough cake	518 52	445 91	542 87	566 90	475 07	435 26	406 34	429 67	396 40	362 66
Lead	English pig	108 44	97 69	90 64	88 45	97 20	113 24	107 41	100 19	105 43	99 53
	English (W. B.)		103 53	96 33	96 59	105 46	118 50	113 24	113 36	112 20	108 76
Zinc, English bar		99 57	111 11	91 49	90 27	110 67	130 01	113 36	117 36	116 28	105 71
Silver (per ounce*)		1 24½	1 23½	1 22½	1 22½	1 22½	1 20	1 18½	1 15½	1 06½	1 11
Coal	Cheapest	3 28	3 40	3 89	4 09	5 69	7 23	5 67	4 56	4 27	4 01
	Dearest	5 53	4 55	4 13	4 57	5 95	7 78	6 05	5 89	4 96	4 49

*English standard, 0.925 fine.

Production of metals and minerals in the United Kingdom.

Weight.

TABLE III.—*Weight of metals and minerals produced in the United Kingdom.*

Metal or mineral.	IN THE YEARS									
	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
Gold ..... ounces..	.....	1,664	191	.....	.....	.....	385	579	293	143
Pig-iron ..... tons..	3,826,752	4,819,254	5,963,515	6,627,179	6,741,929	6,566,451	5,991,408	6,365,462	6,555,997	6,608,664
Copper ..... do...	15,966	11,888	7,175	6,280	5,703	5,240	4,981	4,322	4,694	4,486
Tin ..... do...	6,656	9,088	10,200	11,320	9,560	9,972	9,942	9,614	8,500	9,500
Lead ..... do...	63,225	67,251	73,420	69,037	60,420	54,235	58,777	57,435	58,667	61,402
Silver ..... ounces..	549,090	724,856	784,562	761,490	628,920	*531,077	509,277	487,358	483,422	501,435
Zinc ..... tons..	4,357	4,040	3,986	4,966	5,191	4,471	4,470	6,713	6,641	†6,281
Clay ..... do...	508,666	1,126,924	1,200,000	1,255,000	1,200,000	1,785,000	2,436,912	3,008,444	3,971,123	2,961,155
Salt ..... do...	1,070,973	921,826	1,489,450	1,505,725	1,309,497	1,785,000	2,306,567	2,316,644	2,273,256	2,735,001
Coal ..... do...	80,042,666	98,150,567	110,431,192	117,352,028	123,497,316	127,016,747	125,043,257	131,867,105	133,344,766	134,610,768
Pyrites ..... do...	135,669	114,195	58,429	61,973	65,916	58,924	56,208	48,096	48,810	43,949

*In the "Mineral Statistics" for 1873 the amount of silver given in the introduction is 537,707 ounces. On p. 40 it is given at 524,307 ounces. The number here stated appears on p. 51 and is retained in subsequent reports.

†This is the number given in the introduction to the "Mineral Statistics," and corresponds better to the average market price than that given on p. 38.

Production of metals and minerals in the United Kingdom.

Value.

TABLE IV.—*Value of metals and minerals produced in the United Kingdom.*

Metal or mineral.	IN THE YEARS									
	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
Gold	.....	£5,824	£750	.....	.....	.....	£1,540	£2,105	£1,138	£656
Pig-iron	£12,703,950	11,774,220	14,908,787	£16,667,947	£18,540,304	£18,057,739	16,476,372	15,645,774	16,062,192	16,191,236
Copper	1,706,261	1,134,664	551,809	475,143	583,232	502,822	447,891	388,984	392,300	340,067
Tin	871,382	971,278	1,299,505	1,498,750	1,450,990	1,329,766	1,077,712	866,266	675,750	695,102
Lead	1,417,415	1,433,161	1,452,715	1,251,815	1,209,115	1,268,375	1,298,463	1,290,373	1,270,415	1,262,600
Silver	151,173	199,335	106,140	190,372	157,230	131,077	127,319	115,747	106,222	114,877
Zinc	89,536	104,810	74,096	92,743	118,076	120,099	106,773	162,790	158,011	136,612
Other metals	.....	150,000	3,500	3,000	2,500	5,000	3,000	4,707	2,790	1,750
Total metals	16,939,717	15,773,287	18,496,802	20,179,770	22,070,447	21,409,878	19,539,070	18,476,716	18,668,818	18,742,960
Coal	20,010,674	24,537,646	27,607,798	35,205,608	46,311,143	47,631,280	45,849,194	46,163,486	46,670,668	47,113,767
Clay	221,150	373,916	450,000	475,000	450,000	656,300	780,159	753,957	744,224	592,231
Salt	589,114	440,000	744,725	752,862	654,748	892,500	1,153,282	1,158,322	1,136,628	1,504,250
Other minerals	*170,927	620,580	656,975	708,653	707,078	133,034	512,657	935,177	1,006,515	328,199
Total metals and minerals	37,930,982	41,745,429	47,956,300	57,321,893	70,193,416	70,722,992	67,834,312	67,487,668	68,226,853	68,281,406

*Including metals.

TABLE V.—*Importation, exportation, and consumption of metals and minerals.—Data for the United Kingdom.*

	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Iron:										
Importation, wrought and steel	57, 849	58, 258	113, 967	104, 409	130, 047	117, 196	134, 240	157, 169	163, 774	181, 020
Exportation	1, 441, 067	1, 615, 189	2, 825, 575	3, 169, 219	3, 382, 762	2, 957, 818	2, 487, 522	2, 457, 306	2, 265, 018	2, 390, 551
Consumption	2, 443, 534	3, 262, 323	3, 251, 907	3, 562, 369	3, 489, 214	3, 725, 834	3, 638, 126	4, 065, 325	4, 454, 758	4, 899, 133
Tin:										
Imported metal	2, 911	5, 699	4, 715	8, 583	8, 342	7, 791	9, 218	16, 788	15, 222	13, 762
Metal imported in the ore	438	409	219	336	558	3, 775	3, 500	246	184	190
Exportation	3, 269	7, 191	6, 207	7, 770	8, 126	7, 201	10, 113	9, 267	10, 247	10, 605
Consumption	6, 736	7, 955	8, 927	12, 469	10, 334	14, 337	12, 547	17, 381	13, 059	13, 447
Copper:										
Imported metal	13, 142	23, 137	30, 724	33, 228	49, 000	35, 340	39, 906	41, 031	39, 145	39, 743
Metal imported in the ore	18, 715	23, 922	27, 025	23, 671	21, 702	26, 756	27, 894	29, 483	36, 191	53, 562
Exportation	26, 117	41, 398	53, 006	56, 633	53, 195	55, 716	59, 742	51, 870	52, 468	54, 088
Consumption	16, 708	17, 549	11, 918	6, 546	23, 210	12, 120	13, 039	23, 866	27, 562	43, 728
Lead:										
Imported metal	22, 171	34, 983	60, 064	65, 225	70, 282	63, 078	62, 303	80, 172	80, 719	94, 412
Metal imported in the ore	608	4, 188	9, 237	15, 645	10, 920	8, 766	11, 295	8, 937	9, 400	9, 696
Exportation	23, 797	32, 788	61, 512	45, 649	46, 831	33, 376	42, 049	38, 900	39, 006	45, 411
Consumption	62, 207	73, 634	81, 209	104, 258	94, 791	92, 703	90, 326	107, 644	109, 780	120, 100
Zinc:										
Imported metal	24, 416	32, 191	31, 103	29, 694	27, 118	32, 501	34, 338	37, 870	49, 185	51, 196
Metal imported in the ore	1, 440	1, 547	18, 020	11, 520	9, 785	8, 939	8, 117	7, 470	4, 171	7, 124
Exportation	9, 483	8, 244	10, 687	8, 807	7, 273	4, 486	5, 536	6, 528	7, 000	7, 300
Consumption	20, 730	29, 534	42, 372	37, 373	34, 821	41, 425	41, 889	45, 525	52, 997	57, 301
Pyrites:										
Importation	85, 271	193, 626	411, 512	454, 542	517, 626	520, 347	498, 637	537, 555	504, 752	679, 312
Consumption	220, 940	307, 821	469, 940	516, 515	583, 542	579, 271	554, 845	585, 591	553, 562	723, 261
Coal:										
Exportation	7, 321, 332	9, 170, 477	11, 702, 649	12, 747, 989	13, 198, 494	12, 617, 566	13, 927, 205	14, 544, 916	16, 299, 077	15, 420, 050
Consumption	72, 720, 366	88, 980, 110	98, 728, 543	104, 604, 039	110, 296, 822	114, 390, 181	111, 116, 052	117, 322, 189	117, 045, 689	119, 190, 713

TABLE VI.—*Tin: Principal sources of supply and points of destination of metal and ore handled in England.*

Sources of supply and points of destination.

IMPORT OF ORE.

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.
Australia	120	222	164	192	812	4,726	3,656	60
Chili	.....	79	105	187	18	157	28	.....
Holland	.....	1	.....	7	43	1	1	1
Peru	516	307	70	150	101	671	535	296
Straits	6	14	.....	.....	.....	1	1	26

IMPORT OF METAL.

Australia	.....	9	.....	10	50	494	4,024	7,218
Chili	2	13	150	209	79	114	43	58
Holland	517	510	2,060	1,866	298	1,770	452	467
Peru	65	17	16	284	448	387	367	202
Straits	2,289	4,962	2,335	5,456	6,095	4,812	4,177	8,566

EXPORT OF METAL.

Russia	519	490	659	681	625	957	780	923
Turkey	270	221	243	328	477	388	451	362
France	1,173	1,027	1,455	2,367	2,490	1,556	2,124	2,420
Germany	155	528	868	739	978	718	1,150	1,371
United States	194	2,943	2,079	1,699	1,462	1,720	3,489	1,682

TABLE VII.—*Copper: Principal sources of supply and points of destination of metal and ore handled in England.*

IMPORT OF ORE (INCLUDING REGULUS).

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Australia	8,666	11,261	14,817	6,456	1,258	1,778	589	329	.....	.....
British North America	126	438	7,069	3,970	5,624	6,845	5,069	9,069	.....	.....
Bolivia	7,153	4,965	4,548	4,479	3,355	3,026	5,401	3,888	.....	.....
Chili	48,000	58,314	43,350	30,081	24,796	35,509	29,977	34,495	24,259	24,980
Cuba	16,605	16,820	889	201	46	.....	.....	408	.....	.....
South Africa	3,512	4,156	6,926	6,414	12,678	11,127	12,789	12,464	*14,059	*14,060
Spain	4,704	3,254	9,807	8,590	7,233	6,137	5,513	5,268	.....	.....
IMPORT OF METAL.										
Australia	1,846	2,135	4,594	7,447	11,681	10,616	10,350	11,409	9,928	10,947
Chili	7,266	16,489	22,051	20,773	27,534	20,332	21,724	25,212	26,170	25,754
France†	1,011	379	1,297	652	1,503	231	463	734	.....	.....
EXPORT OF COPPER.										
British India	8,910	10,422	12,352	9,244	5,217	5,165	8,002	9,864	.....	.....
France	5,078	9,821	10,131	8,849	6,200	12,584	14,276	6,791	.....	.....
Germany	1,398	3,026	5,220	8,216	8,473	6,273	7,775	7,734	.....	.....
Holland	1,689	4,228	4,899	6,434	13,353	6,852	7,430	6,570	.....	.....
Italy	1,228	1,865	2,111	2,002	17,090	1,888	2,142	2,575	.....	.....
Russia	42	817	3,725	5,721	17,095	3,129	4,599	3,927	.....	.....
United States	622	503	115	143	4,325	3,765	811	271	.....	.....

*Ore only. The amount of regulus imported from South Africa is small; in 1875 it was 34 tons.
†Not including copper manufactures. The value only is given and includes engraved plates. Calculation of the weight from the value would be very uncertain.

TABLE VIII.—*Lead: Principal sources of supply and points of destination of metal and ore handled in England.*

IMPORT OF ORE.

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Australia	269	710	699	1,033	629	659	1,623	2,108	.....	.....
France	.....	23	839	964	1,311	1,787	1,235	1,587	.....	.....
Italy	321	4,197	7,881	7,768	5,820	6,428	8,144	5,712	.....	.....
Portugal	107	147	1,157	1,245	871	329	766	1,252	.....	.....
IMPORT OF METAL.										
Belgium	1,245	2,240	236	95	256	2,277	1,951	3,058	.....	.....
Greece	.....	.....	9,567	8,800	9,514	7,133	1,411	1,722	.....	.....
Holland	1,205	2,446	3,171	2,006	3,455	2,690	1,875	1,261	.....	.....
Portugal	238	30	1,022	1,670	2,250	2,285	2,829	2,196	.....	.....
Spain	17,737	27,474	42,558	49,455	53,484	47,451	52,560	69,957	.....	.....
EXPORT OF METAL.										
British India	1,317	829	3,038	2,953	2,834	1,177	1,743	1,843	1,883	2,459
China	5,171	2,191	12,495	9,548	7,082	3,935	8,963	9,781	10,848	15,332
France	1,116	4,552	3,326	2,463	2,022	1,494	2,982	2,834	1,792	1,501
Germany	675	360	3,300	3,959	5,161	3,647	2,616	3,056	1,286	1,404
Russia	4,812	1,867	7,460	5,111	8,481	8,063	11,435	9,998	9,055	7,490
United States	4,155	8,227	12,556	11,151	8,353	2,919	3,421	485	1,314	2,906

GREAT BRITAIN.

TABLE IX.—*Zinc: Principal sources of supply and points of destination of metal and ore handled in England.*

Zinc.

IMPORT OF ORE.

Sources of supply and points of destination. Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
France	796	1,519	2,246	1,058	843	1,4-6	710	.....
Italy	.....	.....	31,417	20,761	25,266	21,693	14,734	17,295
Norway and Sweden	138	75	1,444	945	1,439	1,114	328	55
Spain	3,434	3,545	9,162	6,086	5,010	5,129	5,201	3,500

IMPORT OF SPELTER AND MANUFACTURED ZINC.

Belgium	3,431	3,240	16,786	17,175	10,329	3,781	6,310	13,631
France	363	427	432	389	1,965	3,298	1,375	2,247
Germany	18,942	18,354	3,492	5,879	7,115	11,522	11,882	11,468
Holland	1,593	3,886	4,632	6,027	7,483	3,514	3,890	10,011

EXPORT OF SPELTER AND MANUFACTURED ZINC.

Australia	232	526	424	242	403	505	782	962
British America	116	130	165	242	195	102	806	372
British India	5,988	3,095	5,991	5,998	4,962	1,906	2,108	2,975
France	1,527	2,008	1,912	597	59	541	564	793
Turkey	63	240	235	190	211	280	25	.....
United States	.....	1,310	448	253	419	39	185	111

Pyrites.

TABLE X.—*Pyrites: Principal sources of supply of the mineral treated in England.*

Sources of supply. Countries.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Spain	16,393	150,996	242,163	257,429	246,692	294,117	344,019	419,068
Portugal	187,787	174,459	120,573	180,329	199,559	162,569	165,433	56,579
Norway	22,229	67,467	74,416	71,665	67,462	41,044	21,320	7,688
Holland	14,727	14,914	12,809	5,682	.....	.....	.....	.....

GREAT BRITAIN.

Coal.

Points of destination of exports.

TABLE XI.—*Coal and coke: Principal points of destination of fuel exported from England.*

Countries.	1860.	1865.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
British India	298, 102	.....	426, 019	573, 261	528, 806	533, 396	644, 607	608, 150	759, 895	895, 963
Chili	49, 924	.....	81, 507	103, 849	228, 455	136, 906	210, 763	240, 605	.....	160, 460
Denmark	418, 856	618, 223	704, 537	658, 701	641, 508	592, 789	662, 289	749, 899	779, 822	765, 608
Egypt	111, 997	.....	408, 405	455, 469	509, 770	526, 895	617, 078	590, 252	545, 897	520, 476
France	1, 264, 872	1, 562, 627	2, 066, 444	1, 977, 198	2, 154, 041	2, 402, 177	2, 261, 409	2, 610, 895	3, 250, 564	3, 010, 148
Germany	1, 113, 278	1, 255, 301	1, 603, 249	2, 396, 511	2, 118, 564	1, 668, 680	2, 056, 881	2, 172, 319	2, 278, 905	2, 042, 911
Holland	815, 981	231, 797	412, 057	506, 805	471, 259	468, 058	447, 209	454, 019	480, 891	411, 655
Italy	468, 426	455, 228	768, 573	808, 895	906, 925	764, 045	909, 868	987, 868	1, 218, 614	1, 072, 928
Russia	856, 781	466, 988	829, 585	913, 788	794, 763	612, 069	883, 435	895, 195	1, 187, 020	1, 026, 803
Spain	460, 692	888, 971	577, 698	554, 818	592, 567	576, 095	544, 319	648, 605	762, 569	826, 471
Sweden	214, 729	241, 496	385, 864	397, 550	507, 608	532, 842	690, 270	740, 824	1, 145, 617	775, 984
United States	309, 869	.....	107, 669	151, 946	108, 271	87, 641	111, 679	92, 906	.....	138, 614

IV.

AUSTRALIA.

THE AUSTRALIAN EXHIBIT.

Four colonies represented.

The Australian colonies represented at the Exposition, viz, Queensland, New South Wales, Victoria, and South Australia, made a fine exhibit of ores and metals and of photographs of localities and mining operations. Mining appliances were, unfortunately, absent, but on the other hand descriptive and statistical information were freely distributed.

A collection of ores and products must be supplemented by statistics.

After all, an exhibit of ores and products serves as little more than an illustrated index to the mineral industry of a country. For any comprehensive view of the subject one must necessarily have recourse to printed information, whether statistical or technical.

An attempt will be made in the following pages to present such a sketch of the mining industries of the great southern continent as it is supposed will be welcome to Americans, not altogether neglecting applied science nor omitting to trace the developments and achievements of the purely commercial side of mining. The astonishing variety and abundance of the mineral resources of Australasia, and more particularly of New South Wales, and, as it seems, of the islands of New Zealand, where development has scarcely yet begun, make them an interesting subject for the technologist and an important one to those who "go down to the sea in ships."

Extraordinary variety and abundance of Australia's mineral resources.

The sources of the author's information.

An extensive but somewhat desultory literature of the Australian mineral resources exists. The writer has availed himself, in addition to the catalogues, essays, and pamphlets distributed at Paris, of a variety of works and scattered memoirs, and would gladly have extended his inquiries to many publications not within reach. It is not too much to hope that one result of the approaching International Exhibition in Australia will be a wider dissemination in America of the valuable documents in the publication of which the colonial governments have shown a most intelligent regard for technology and science.

The approaching Melbourne International Exhibition of 1880.

It has been the writer's intention to accredit all information to the proper sources.

The mineral resources of Australia.

Its mineral resources.

So little attention is, in general, devoted to Australia, the character of the country, and its resources, that a few words of general description may not inappropriately precede an account of its mineral industry.

Area of Australia about the same as the United States, Alaska excluded. Aridity of interior.

Australia has an area of 3,000,000 square miles, or approximately the same as that of the United States, excluding Alaska. The interior of the continent is a desert, and one-third of it is practically unexplored. Leaving out of consideration the comparatively insignificant colony of West Australia, the interest concentrates upon four colonies in the eastern and southeastern portion of the territory. The eastern side of the continent is occupied by Queensland, New South Wales, and Victoria. Queensland is the most northerly and the largest of the colonies; Victoria the southernmost, smallest, and most populous. On the south shore and immediately west of New South Wales and Victoria lies South Australia. The four colonies offer a continuous coast, occupying perhaps three-eighths of the circumference of the continent. The settlements cover a strip of country extending two or three hundred miles inland, and amounting to perhaps one-fifth of the area of Australia. The population of these four colonies exceeds 1,600,000.

The eastern colonies, and the southern.

Settlements and population.

Physical character of Eastern Australia similar to the Pacific coast of North America.

The physical character of Eastern Australia is remarkably regular and resembles Western America in its most striking features, essentially as it differs from the Pacific coast in a geological aspect.

The coast range, and divergent spurs.

From one end to the other of the east side runs a chain of cordilleras parallel to the coast. The main ranges are at an average distance of not more than 100 miles inland, and their average elevation is not over 1,500 feet, although peaks in the southern portion rise to 7,000 feet. Subordinate parallel ranges and divergent spurs occupy a tract of country extending some hundreds of miles from the coast, and the main range turns westward for some 400 miles at its southern extremity, still following the shore line. It is almost a matter of course that the line of the great cordillera should experience local deflections from its general direction, and these deviations would not be referred to but for the extraordinary fact that strike of the slates and other older sedimentary strata upheaved along this chain preserves a meridianal course irrespective of the mountain formation. The strike of the slates consequently crosses the westerly branch in which the cordillera terminates at its southern extremity at right angles, and crosses more northerly bends in the chain

Upheaval of the older sedimentary strata.

AUSTRALIA.

Its mineral resources.

at an angle equal to their deviation from the meridian; and so strictly uniform is this line of fracture that bewildered travelers in the mountains refer to the slates to regain their bearings.

Comparison of Australian and the Pacific coast.

It was once supposed that the geology of Australia and the Pacific coast were nearly allied, and analogies there unquestionably are; but these tend rather to prove the prevalence of similar physical and chemical conditions in various geological eras than the coeval development of the mineral resources of the two most important gold-bearing regions of the world. In fact, so far as the formations found in the two localities are concerned, they may be said to be almost antithetical, in some respects much to the advantage of Australia.

Indications of similar physical and chemical conditions at different geological eras.

Rocks specially developed in Western Australia.

In Western Australia Archæan granites are largely developed, while the Silurian is represented only by occasional patches. The Tertiary is well developed in Western Australia and along the southern coast into Victoria. On the eastern coast, with its cordillera, however, it is doubtful whether any Azoic rocks have been found, the crystalline schist, etc., being referred to the lower Silurian. Paleozoic rocks are very highly developed, as are also the Mesozoic, while except at its northern and southern extremities the great mountain belt of Eastern Australia lacks the Tertiary.

Absence of certain rocks in the eastern coast range.

The eastern cordillera.

The eastern cordillera of Australia is then a mountain range which has been upheaved in Paleozoic and Mesozoic formations. The disruption has been accompanied by outbursts of igneous rocks, apparently of many different ages; and this action has been accompanied by more or less metamorphosis or transmutation.

Its upheaval, disruption, etc.

These are plainly geological conditions likely to be accompanied by ore deposits, and such there are in wonderful variety, covering a belt coincident with that of the settlements, two or three hundred miles wide and 1,700 miles long.

Vast ore deposits on a belt of 250 by 1,700 miles.

There is a second belt of mineral deposits in South Australia, where there exists a comparatively small range of mountains, also running north and south, at a distance of some 700 miles west of the more important chain. The predominant ores in the South Australian chain are those of copper, and in their parallelism and difference of mineralization we recognize an analogy to the successive ore-bearing belts of the region of the Pacific. New Zealand may be regarded as a second parallel mineral belt.

Parallel ore belt of South Australia, and of New Zealand.

Unequaled variety of valuable minerals

The variety of valuable minerals met with in the Australian coast ranges is unequaled in any other part of the world. Gold, copper, tin, and coal are indeed the principal

mineral products, but several others are of no trifling commercial importance, as bog-head mineral or "kerosene shale," iron, lead, and silver and antimony, while diamonds and a variety of other gems and quicksilver have been sought for with some success.

Its mineral resources.

The importance of the rainfall to mining interests, and more particularly to gold mining, is well known wherever this industry is pursued. In Eastern Australia the rainfall is much as might be anticipated from the general physical features. On the coast the yearly rains amount to, say, from 20 to 50 inches. The quantity diminishes toward the interior, and on the western slope of the cordillera some places escape rain altogether. In California the placer mines are on the wet side of the enormous range of the Sierra Nevada, which serves as a reservoir for a large fall of rain and slowly melting snow. In Australia the comparatively small range of mountains and the distribution of deposits is against the miner, who is often compelled to contend with lack of water.

The rainfall in its influence on mining interests.

Australia and California.

A comprehensive idea of the mineral industry of Australia is less common than it would be but for the political constitution of the country. The four colonies have no political connection, nor is there any co-operation in the matter of surveys, mineral statistics, and the like. Hence data must be sought independently for the mining districts of each colony, although no natural division exists between them. It will be the object of the following remarks to trace briefly the past history and present condition of each of the more important mining industries, independently of political divisions.

The colonial division of the country as affecting the collection of comprehensive mining statistics.

Gold.—It was of course the secondary stream or placer deposits of gold which first attracted attention. It was formerly supposed that these gravel deposits containing water-worn gold were of recent origin. It has been shown, however, that the period of their formation extends back into the Paleozoic eras. Mr. C. S. Wilkinson writes as follows: "North of Gulgong, at Tallawang, the coal measures cover a large area of country; their lowest beds have been found to be payably auriferous. * * * The gold is coarse in size, remarkably scaly, and water-worn. * * * These alluvial deposits are of four periods, Pliocene, Upper Pliocene, Pleistocene, and Recent; and now we can add another—the Carboniferous—the oldest formation as yet discovered containing drifted or water-worn gold." Rev. W. B. Clarke had previously discovered minute quantities of gold in carboniferous conglomerate. As in California, the auriferous

Gold.

The placer deposits the first to attract attention.

C. S. Wilkinson.

The periods of the alluvial deposits.

Rev. W. B. Clarke.

AUSTRALIA.

Its mineral resources.

gravels are not infrequently covered with beds of volcanic rock.

Gold.

Gold is also found in place, and a very large proportion of the metal now yearly extracted is obtained from veins. For a time it was maintained that these veins were remunerative (the Australians use the somewhat ambiguous expression "payable") only in certain formations, and that deep mining must necessarily be unprofitable. It has been conclusively shown, however, that while the majority of paying veins are found in certain formations, rich veins also occur in others, and that there is no tendency of veins otherwise favorably placed to give out in depth.

Gold in veins.

The typical habitus of gold in place in Australia is in quartz veins, and in the southern portion of the gold belt (Victoria) the gold is chiefly derived from veins or "reefs" in the Lower Silurian, without being confined to this formation. In the central portion of the chain of the cordilleras, gold is more generally distributed, and in Queensland "micacious diorite, serpentine, pyritous felstone, and compact quartzite are gangues in many localities, to the total exclusion of quartz." Gold *in situ*, however, is not confined to veins. It is also met with in igneous rocks and sedimentary strata. Mr. Clarke says:* "Much of the gold in New South Wales is derived from iron pyrites in granite, and in *beds* of sedimentary origin. * * * In New Zealand gold sometimes occurs so mixed with siliceous particles as to constitute with them a gold sandstone." Elsewhere† he says of Queensland: "Oftentimes, where there is no reef or vein of any kind, the whole mass of the rock is charged with gold." Mr. Wilkinson states,‡ as a remarkable fact, long since pointed out by Mr. Clarke, that the hornblendic granites of New South Wales are auriferous. In all the gold fields recently examined Mr. Wilkinson has noticed that hornblendic granites and intrusive diorite are the original sources from which the gold in the gravel deposits has been derived. Gold, moreover, seems to accompany iron pyrites everywhere in ancient and recent formations. To leave out less extraordinary occurrences, Mr. Clarke speaks of the discovery of a lump of gold in a lump of coal; and Mr. R. B. Smyth mentions§ that the pyrites from an old tree trunk was examined, the yield of which was at the rate of over 30 dwt. per ton.

The origin of the gold in Victoria;

in Queensland;

in New South Wales;

in New Zealand.

The origin of the gold in gravel deposits.

Found in coal.

R. B. Smyth.

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* *Mines and Mineral Statistics of New South Wales*, p. 153.

† *Progress of Gold Discovery in Australasia from* 1860 *to* 1871.

‡ *Annual Report of Department of Mines, N. S. W.*, 1875.

§ *Gold Fields and Mineral Districts of Victoria*, p. 261.

AUSTRALIA.

Its mineral resources.
Gold.
H. A. Thompson.

The physical structure and the lithological character of the surrounding rocks both affect the yield of quartz veins in Australia. Mr. H. A. Thompson, a well-known mining engineer, has observed* that only partially decomposed granites and diorites carry gold-bearing veins, and that if the decomposition of the adjacent rocks penetrates only to a small depth the quartz veins cease or become barren. Veins, too, crossing planes of bedding or stratification, or at the contact between unconformable beds, are richer than others. In short, the conditions for infiltration must exist. It is a mistake to suppose that highly altered strata are indispensable to paying quartz, many of the best veins being in unaltered, soft Silurian beds. The influence of intrusive hornblende granite and diorite is marked, veins which are very rich so long as they are in these rocks losing their gold contents on passing into adjacent schists. The best veins are laminated in structure, and carry large quantities of sulphurets.

Structure and character of the adjacent rocks as affecting the yield.

Relative fineness of Australian and Californian gold.
J. C. Booth.

Australian gold is, on the whole, finer than Californian. Mr. J. C. Booth, of the United States Mint, states† that the average fineness of California gold, derived from assays of several hundred million dollars' worth, is 0.880. In Victoria, which has been the most productive of the colonies, the value of the gold product is officially estimated at £4 per ounce, which corresponds to a fineness of 0.942, nearly. From the data given in *Mines and Mineral Statistics of New South Wales* for the product of that colony up to the end of 1874, I find the average there 0.876. Indeed, Mr. Clarke and others have long ago drawn attention to the remarkable fact that the fineness of Australian gold diminishes from the south northwards, and Dr. Hector has shown that the same law prevails in New Zealand.

In Australia the fineness diminishes from the south northward.
Dr. Hector.

Delay in public announcement of gold in Australia.
Count Strzelecki, 1839.
Rev. W. B. Clarke, 1841.
R. J. Murchison, 1844.

Public recognition of the auriferous character of Australia was curiously delayed.‡ Count Strzelecki discovered gold in Australia in 1839, but was restrained from publishing the statement on account of the danger of its producing insubordination in the penal settlements. In 1841 Rev. W. B. Clarke rediscovered it, but the governor of New South Wales induced him to refrain from mentioning it on account of the prejudicial effect it might have on the colony. In 1844 Murchison pronounced it likely that Australia would be found to be a gold-bearing country. Gold nuggets of small size were sometimes found by shepherds, and not only

* *Gold Fields and Mineral Districts of Victoria*, p. 240

† Dana's *Mineralogy*, p. 5.

‡ See *Gold and Silver*, by Mr. J. A. Phillips.

AUSTRALIA.

brought to the settlements, and even exhibited there, but sent to England. Yet it was not until a returned Californian miner, Mr. E. H. Hargreaves, set to work at Ballarat, that the auriferous character of the country was realized.

Its mineral resources.

Gold.

E. H. Hargreaves.

Ballarat.

Attention once aroused, the discoveries of alluvial "diggings" multiplied with great rapidity, and such were soon discovered from one end of the cordillera to the other. Quartz veins were also soon discovered, and, as in California, an increasing proportion of the gold has been extracted from this matrix.

Area of gold diggings.

The area of the gold diggings varies from year to year, surface deposits being exhausted and abandoned. The following are the most recent data accessible as to the extent of ground being worked in:

	Sq. miles.
Victoria, in 1876	1,134
New South Wales, in 1876	1,370
Queensland, in 1873	1,367
Australia, say	4,000

Yield of quartz per ton.

The yield of quartz per ton (2,240 pounds) varies in the different colonies, and indeed in inverse ratio to the fineness, as might be supposed. The following table represents the gold per ton in the parcels respecting which the mining officers succeeded in obtaining information:

	Oz.	Dwt.	Gr.
Victoria, in 1876		10	13.48
New South Wales, in 1876		13	8.20
Queensland, in 1873	1	14	20

The poorest parcel crushed in New South Wales in 1875 yielded only 1 dwt., or, say, $1 per ton, and in 1876 quartz scarcely better was milled. The lowest yield should indicate the cost, but such rock can only have been crushed in ignorance of its contents.

Proportion of gold obtained from placers and from veins.

The proportion of gold obtained respectively from alluvial deposits and from veins is not precisely ascertainable. Of the gold, the history of which was learned by the mining officers of New South Wales in 1876, more than two-thirds was obtained from quartz, but the entire quantity thus traced was only something like one-third of the total product, and it is evident that it must be easier to get reports from mills than from diggings. Ten years since, the proportions estimated in Victoria were just the reverse of the above relation. It seems probable, therefore, that the quantities obtained by mining and by washing are very much the same.

New Zealand.

New Zealand did not exhibit at Paris. For the sake of completeness, however, it may be interesting to add a few

words on the subject of that colony, which are translated from the memoir of Dr. A. Soetbeer:*

Its mineral resources.
Gold.
New Zealand.
Dr. A. Soetbeer.

"*New Zealand.*—In 1852 about 1,000 ounces of gold were obtained upon the east side of the north island at Cape Coromandel, after which the workings were abandoned. Four years later a beginning was made at the south, in the province of Otago. A great increase in the gold production of New Zealand took place in the summer of 1861, when new and very rich deposits were discovered on the Tuapeka River and in the Thames gold fields. The north island has thus far produced far less gold than the south island, which is much richer in alluvial deposits.† The most important districts stretch along on the western slope of the mountains through Nelson and Westland Provinces toward Otago. Throughout Otago, where they are especially numerous and rich, their distribution is dependent upon the slate rocks. The younger gold-bearing drifts at the bottom of existing valleys are distinguished from deeper and older alluvia upon the declivities. In fact, the rivers of New Zealand have eroded their beds greatly since the formation of the older alluvia, so that the deep leads, which in other districts can often be reached only with great trouble and expense, are here not infrequently exposed upon the declivities of the valleys.

Successive discoveries of gold districts.

The gold-bearing drifts of different periods.

"Hydraulic washing on the California plan has been introduced in Otago.

"The comparatively small extension of the gold districts among the younger volcanic rocks as contrasted with the great development of alluvia from the slates justifies the prediction that the fate of New Zealand will be that of California."

Product of gold mining in Australia and New Zealand.

The following table exhibits the results of gold mining in Australia and New Zealand. The gold product of South Australia and Tasmania has been fitful and insignificant. The data for Victoria are official reports of the mining registrars; for New South Wales, in part from a similar source and in part from analyses of the mint and custom-house reports, made by the mining authorities of that colony. The data for Queensland and New Zealand are taken from Dr. Soetbeer's memoir. Dr. S. arrives at all his figures for

* *Edelmetall-Produktion und Werthverhältniss zwischen Gold und Silber.* (Production of precious metals and relative value of gold and silver.) This memoir, the most extensive that has appeared on the subject, has just been published as an extra number to "Petermann's Mitheilungen." It seems exhaustively compiled and admirably digested.

† E. Suess, *Zukunft des Goldes*, Wien, 1877.

AUSTRALIA.

Its mineral resources.
Gold.

Australia by discussing the importation and exportation of gold, and allowing a certain amount for circulation, etc., in the colonies. It is satisfactory to find that his final result is only two million pounds, or about three-fourths of one per cent. less than that here given, although less than one-fifth of the total has been reached from the same data.

Table of gold product of Australasia.

Value of the Australasian gold product.

Years.	Victoria.	New South Wales.	Queensland.	New Zealand.	Australasia.
Prior to 1870 ..	£152, 524, 816	£24, 275, 660	£1, 262, 622	£18, 162, 232	£196, 325, 330
In 1870.....	4, 891, 192	931, 016	483. 165	2, 062, 600	8, 367, 973
1871..... ..	5, 421, 908	1, 250, 485	584, 481	2, 008, 740	9, 265, 614
1872..... ..	5, 130, 084	1, 643, 582	438, 613	1, 502, 043	8, 714, 322
1873.....	4, 964, 820	1, 395, 175	623, 199	1, 728, 670	8, 711, 864
1874.....	4, 623, 888	1, 040, 329	1, 313, 204	1, 364, 720	8, 342, 141
1875.....	4, 383, 148	877, 694	1, 434, 219	1, 382, 282	8, 077, 343
1876.....	3, 855, 040	613, 190	1, 246, 296	1, 228, 864	6, 943, 390
Total.....	185, 894, 896	32, 027, 131	7, 385, 799	30, 040, 151	255, 347, 977
Maximum yield ..	11, 943, 964 (In 1856.)	2, 660, 946 (In 1852.)	1, 434, 219 (In 1875.)	2, 784, 124 (In 1866.)	12, 663, 034 (In 1856.)

Or, in money of the United States (taking the pound at $4.86), as follows:

In 1876.....	$18, 735, 494	$2, 980, 103	$6, 056, 999	$5, 972, 279	$33, 744, 875
Total.....	903, 449, 195	155, 651, 857	35, 894, 983	145, 995, 134	1, 240, 991, 168
Maximum yield ..	58, 047, 665 (In 1856.)	12, 992, 198 (In 1852.)	6, 970, 304 (In 1875.)	13, 530, 843 (In 1866.)	61, 542, 345 (In 1856.)

Dr. Soetbeer's estimate.

The mind fails to grasp these sums, but some idea at least may be obtained by comparison. I therefore add Dr. Soetbeer's results for the gold-producing countries of the world, from the discovery of gold in Australia to the end of 1875. I have added the same statistician's estimate of the silver product of the world for the same period for comparison. The silver production of Australia will be mentioned presently. Dr. Soetbeer is responsible only for the weights. These I have converted into terms of the habitual dollar, at the rate of 1 kilo gold to $664,632, and 1 kilo silver to $41,568.

Table of world's product of gold and silver, 1851–1875.

The world's product of gold and silver, 1851 to 1875, inclusive, according to Soetbeer.

Countries.	Gold.		Silver.	
	Kilograms.	Dollars.	Kilograms.	Dollars.
Australia.....	1, 812, 000	1, 204, 310, 000	.....	.....
United States	1, 840, 500	1, 223, 260, 000	5, 271, 500	219, 124, 000
Mexico and South America.	231, 935	154, 150, 000	18, 570, 500	771, 933, 000
Russia	694, 080	461, 310, 000	397, 700	16, 535, 200
Other countries.....	177, 850	118, 205, 000	6, 763, 745	281, 153, 000
Total.....	4, 756, 365	3, 161, 235, 000	31, 003, 535	1, 288, 745, 200

AUSTRALIA.

Of the present methods of treating gold-bearing gravels and quartz in Australia it would be interesting to speak, were the necessary information furnished by the Exposition, but Australia exhibited no mining appliances; a fact which is to be regretted, but of which we cannot complain, as American mining apparatus was equally conspicuous by its absence.

Its mineral resources.

Gold.

Absence of exhibit of gold-mining appliances.

There are few places in Australia where hydraulic mining is practicable, for lack of sufficient water supply. Where alluvial gold is mixed with any adherent material, it has to be "puddled" or stirred up mechanically with water, so that a separation of metal from dirt may be possible; a method avoided in this country almost entirely. Cradles, pans, etc., seem also in vogue in Australian diggings.

Infrequency of hydraulic mining in Australia.

For crushing quartz the stamp mill is there as here almost the only machine employed. Data are not accessible as to their construction and duty, but the inference from what we know is not favorable. In 1876 there were 1,326 stamp-heads at work in New South Wales, according to the report of the Minister of Mines. But if the quartz ran $13.50, and if half the gold was produced from quartz, this large number of stamps must have crushed only in the region of 370 tons per diem. The loss is estimated at 21.8 per cent. Mr. G. T. Deetken calculated the loss at Grass Valley, Cal., at 27 per cent. (Mining Commissioner's Report for 1873, p. 333.)

Stamp mills.

Statistics of the number and performance of stamp mills.

Loss.

G. T. Deetken.

In respect to the treatment of pyrites, the Australian colonies are making vigorous efforts to develop some method more economical or better suited to the ordinary conditions of gold-mining localities than has hitherto been brought to public attention. The Plattner chlorination process has done good service in California, but only pyrites carrying $20 or so per ton will pay for treatment. In England vast quantities of pyrites are treated at small cost, but in connection with the sulphuric acid manufacture and iron smelting; industries ordinarily absent from gold-mining localities. A process for the treatment of this material should be self-contained, or nearly so, and admit of the utilization of at least the copper and silver as well as the gold. The subject is one well worthy of the attention of California engineers, who will find, among other Australian publications, a paper by Mr. W. A. Dixon in the eleventh volume of the *Journal of the R. S. of New South Wales* of interest.

Treatment of pyrites.

Plattner's chlorination process.

A new process desirable to save the copper and silver as well as the gold.

W. A. Dixon.

Silver.—But little attention has been paid in Australia to silver ores. It may, however, be worth while to point out that native gold always contains silver, and that conse-

Silver associated with the gold.

AUSTRALIA.

quently a very considerable quantity of silver has accompanied the Australian gold product into commercial channels.

Its mineral resources.

Silver.

The value of this silver is relatively so small, that it cannot be taken into consideration in the official estimates of the value of the gold product. In Victoria the value of the gold per ounce is estimated at four pounds, corresponding to a fineness of nearly 0.942, or about 22½ carats. The remaining 0.058 silver would have a value amounting to less than one-half of one per cent. of the total value of the bullion, and it is pretty certain that the official estimate does not possess this degree of accuracy.

Value of the silver associated with the gold.

In spite of the inaccuracy of the estimate of the mean value of the gold bullion, the data may be used to estimate the amount of silver obtained with the gold. The records show that the average fineness of Australian gold is not far from 22 carats, or 0.916⅔. The weight of the silver contents of the gold bullion has, then, been one-eleventh of that of the gold. If one ounce of silver is taken, according to American law, at $1.2929, this calculation leads to an amount of silver worth a little over seven million dollars on my estimate of the gold product up to the end of 1876.

Amount of silver contents of the gold bullion.

Silver ores.

Ores the valuable contents of which is distinctively silver are found in patches through the gold districts of Australia, not, as in Western America, in separate belts of country.

Product in Victoria to 1876.

The amount of silver produced from silver ores in Victoria to the end of 1876 is officially estimated at a value of £21,206. New South Wales has produced, up to the same date, £105,466 worth of this metal. Queensland appears to claim no silver product. The value of the silver from silver ores has there amounted only to some $600,000.

In New South Wales.

Tin.

Tin.—The uniformity in the character of tin deposits all over the world has long been a subject of remark, and Australia has no exception to offer. Here, too, it occurs in alluvial deposits of various ages, and in place in lodes and reticulated veins, less properly described as "strings," in granite and greisen rocks. Mr. D. Forbes, as far back as 1859, received specimens of stanniferous granite from New South Wales, and found them "perfectly identical with the stanniferous granites of Cornwall, Portugal, Bolivia, Peru, and Malacca," and Banca and Billiton might have been added to the list. The tin ore is frequently found associated with gold, which indeed it greatly resembles in its lithological behavior. It is nearly always associated with quartz, many crystals of the latter mineral showing crystals of cassiterite imbedded in and implanted upon them, whence the conclusion seems inevitable that their deposition has been

Alluvial deposits and lodes.

D. Forbes, 1859.

Stanniferous granite.

Tin ore found associated with gold.

Crystals of cassiterite in quartz.

Its mineral resources.

Tin.

simultaneous. Arsenical and copper pyrites are also associated with the tin-stone, and diamonds and sapphires occur in the same leads. Their high specific gravity and perfect resistance to atmospheric action account in part for the occurrence of gold and tin-stone together in alluvial deposits.

Stream deposits.

The stream deposits are not confined to the beds or banks of present water-courses. They often extend high up the sides of the valleys of the present streams (indicating erosion), and are also found in "deep leads" or the beds of ancient streams. The only source of the tin seems to be the granites. On high ground, cassiterite is sometimes found over granite in unworn crystals, and existing there as a residuary deposit. The granites are Paleozoic, and, according to Mr. Clarke, Devonian. The veins do not exhibit a uniform strike as in Cornwall.

Deep leads.

Granites the source of tin.

Localities of the tin fields.

The tin fields of Australia center on the eastern cordillera, about half-way up the coast, and near the boundary between New South Wales and Queensland, though there is tin ore in the southern portion of New South Wales and in Victoria, and very valuable discoveries have been made in Tasmania.* The area of the New South Wales fields is estimated at 6,250 square miles, and that of the Queensland tin-bearing district at 100 square miles.

Areas.

Rev. W. B. Clarke.

Rev. W. B. Clarke, whose active share in the investigation and development of the mineral resources of Australia has so often been referred to, was the first to draw attention to the probable occurrence of extensive deposits of tin ore in Australia. His prediction was made in a report to the colonial secretary of New South Wales, dated May 7, 1853, the subject of which was the district of New England, the same which became so famous for its tin deposits in 1872. No practical notice was taken of Mr. Clarke's observation.

His prediction in 1853 of the discovery of tin ore deposits.

Tin-stone in Victoria.

The existence of tin-stone was recognized in Victoria during the same spring. The occurrence of tin in the more southern colony is comparatively trifling, but the discovery was not entirely overlooked as in New South Wales. As has been pointed out in the report on the mineral industry of Great Britain, relatively considerable quantities of tin-stone and tin were obtained in Australia long before 1872. This appears to have come exclusively from Victoria, which still produces a few scores of tons a year, a quantity quite insignificant in comparison with the recent yield of New

*See paper by Mr. Wintle, *Trans. R. S. of New South Wales*, vol. 9, p. 87. The deposits seem to present great peculiarities, the ore occurring in sharp detritus and often in lumps weighing hundreds of pounds.

AUSTRALIA.

Its mineral resources. Tin.

South Wales and Queensland. According to the *Victorian Year Book* for 1876–'77, the total value of the tin raised since its first discovery in that colony was £336,391, representing, perhaps, 3,000 tons of metal. The product of 1875 and 1876 cannot have been far from 60 tons per year.

Product of Victoria.

Tin in New South Wales.

The fact of the existence of tin-stone in the northern part of New South Wales fell so entirely into oblivion that in a government volume entitled *Industrial Progress of New South Wales in* 1871, an essay on the mineral resources of the colony contains no mention of this metal. Since 1872 great quantities of tin have been extracted, mainly from stream deposits, and the business of tin smelting has been rapidly mastered. The returns of the tin raised and smelted are confessedly imperfect.

In Queensland.

As the great tin fields lie close upon the borders of New South Wales and Queensland, the discovery of tin-stone in the latter colony was simultaneous with that in the former. The data accessible to me for the production in Queensland are exceedingly unsatisfactory, for in 1874 I have the product for the first quarter only, for 1875 nothing, and for 1876 only a statement of the value. In the following table I have calculated the contents of the tin-stone raised at 70 per cent. metal, and estimated the missing figures as well as I could. These unauthoritative sums are printed in bold-faced figures:

Table of production of tin in Australia.

Approximate production of tin in Australia.

Years.	NEW SOUTH WALES.		QUEENSLAND.		Total probable equivalent in tin.
	Tin and tin ore produced.	Probable equivalent in tin.	Tin ore produced.	Probable equivalent in tin.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1872	Ore ... 848 / Tin ... 47	**598**	1,400	**980**	**1,578**
1873	Ore ... 3,635 / Tin ... 904	**3,449**	5,274	**3,692**	**7,141**
1874	Ore ... 2,118 / Tin ... 4,101	**5,584**	**5,440**	**3,808**	**9,392**
1875	Ore ... 2,022 / Tin ... 6,058	**7,473**	.....	**3,500**	**10,973**
1876	Ore ... 1,509 / Tin ... 5,449	**6,505**	.....	**2,800**	**9,305**
Total	.....	**23,609**	.....	**14,780**	**38,389**

English tin product.

Or, adding **3,000** tons for Victoria, the total becomes, say, **41,000** tons. The English tin product for 1876 was

AUSTRALIA.

9,500 tons; Banca and Billiton produced together about 6,600 tons.

Its mineral resources.

Mr. Wilkinson attributes the falling off in the tin product to the exhaustion of the more accessible alluvial deposits.

Tin.

The washing of the tin-stone is effected either in sluices or jigs. As in the treatment of placer gold, the lack of an ample water supply is severely felt. Wolfram seems not to occur with the tin-stone to any considerable extent. The smelting is effected, as in England, in reverberatory furnaces.

Washing in sluices or jigs.

Smelting.

Copper.—South Australia contains some of the finest copper mines in the world. The following somewhat meager account is extracted from a *Statistical Sketch of South Australia*, by Mr. J. Boothby:

Copper.

South Australia.

J. Boothby.

"The principal mines are the Burra, the Wallaroo, and the Moonta.* From the first of these 215,000 tons of ore were raised during 31 years from the commencement of operations, producing four millions sterling. The total amount expended by the company was £1,982,000, of which £1,568,000 represented wages, the gross profits being £882,000. Since the opening of the Wallaroo mines, the total quantity of ore raised therefrom has been 290,000 tons, and the average of the past five years has been 26,000 tons. The Moonta mines were discovered in 1861, since which year 250,000 tons of ore have been raised, realizing £2,760,000. A profit of £928,000 has been divided amongst the shareholders of this magnificent property.

Product of the principal mines.

Burra mines.

Expenses and profits.

Wallaroo mines.

Moonta mines.

"In 1844, shortly after the discovery of copper in South Australia, the total value of the minerals exported was £6,436; in 1851 it reached to £310,916; in 1861 it amounted to £454,172; in 1871 to £648,569; in 1875 to £762,386.

Minerals exported, 1844–1875.

"The following table exhibits the steady productiveness of South Australian mines, distinguishes the quantity of fine copper shipped from the quantity of ore exported in its crude state, and gives the estimated value of each:

Product of South Australian mines, 1866–1875.

Years.	Fine copper.		Copper ore.		Total value.
	Cwt.		*Tons.*		
1866	129,272	£584,509	16,824	£225,683	£824,501
1867	156,863	627,384	11,430	113,409	753,413
1868	104,227	400,691	20,725	207,519	624,022
1869	92,788	371,566	26,835	250,259	627,152
1870	109,421	394,919	20,886	173,861	574,090
1871	127,911	518,080	20,127	119,903	648,569
1872	149,050	680,714	26,964	122,020	806,364
1873	141,744	635,131	27,382	135,371	770,590
1874	132,587	557,306	22,854	136,530	700,328
1875	136,835	578,065	26,436	175,101	762,386

* Burra is 60 miles from Adelaide, on the eastern slope of the South Australian range. Wallaroo and Moonta are close together, 75 miles from the capital, near the base of Yorke Peninsula.

AUSTRALIA.

Its mineral resources.

Copper.

"The smelting works in connection with these mines are of a very extensive and costly character, employing a large amount of skilled labor."

Distribution of the copper ore.

Copper is also found in large quantities along the eastern cordillera, distributed over a somewhat wider belt of country than the ores of the other metals. The copper in the eastern colonies, however, labors under some disadvantages in the unfavorable position of the mines for transportation, the large capital necessary to establish smelting works, etc. The returns of copper ores raised and smelted, as well as those of tin, are very imperfect. Up to 1874 the maximum quantity of metallic copper produced in New South Wales was 665 tons; but for the years 1874, 1875, and 1876, respectively, the ingots exported weighed 3,628, 6,245, and 3,106 tons. A small quantity of ore and regulus continues to be exported. The total value of the copper industry in New South Wales before 1874 is estimated officially at about £500,000, and for the years 1874, '75, and '76 together at a little over a million.

Copper production of New South Wales.

Queensland.

Queensland produces some copper ore, and copper mining is there regarded as one of the industries of the future. The value of the copper and copper ore exported in 1872 was £234,540; in 1873, £189,479; and in 1876, £172,380. Copper has figured among the exports of Queensland ever since 1862.

Victoria.

Victoria produces only a trifling amount of copper, the amount raised up to the end of 1876 being valued at only £8,331.

Copper product of Australia.

These desultory data convey very little idea as to how much copper Australia has produced. A rough approximation may be made as follows:

Value of copper and copper ore raised in South Australia to the close of 1875	£14,404,568
From the product of former years we may estimate for 1876	750,000
Value of copper product of Victoria to end of 1876	8,331
Value of product of New South Wales to end of 1876	1,566,232
Value of Queensland product to end of 1873	955,592
Value of Queensland product for 1876	172,380
Value of Queensland product for 1877 and 1875, estimated same as 1876	344,760
Total value of Australian product	18,201,863

Value of Australian copper product.

Price of copper.

The average price of copper (tough cake) in England for the years 1870 to 1876 (7 years) was within twopence of £84 10*s*. But a large proportion of the copper raised in Australia was exported as ore and valued accordingly. The

AUSTRALIA.

Its mineral resources.

Copper.

price of copper ore containing 20 per cent. copper, in Swansea, is about 80 per cent. of the market value of the copper therein contained. For lack of data we may suppose one-half of the copper in ingots and one-half as ore; or that the value per ton of the copper raised as it was exported was 90 per cent. of the market price of tough-cake copper, or, say, £76 per ton. This assumption leads to a total copper product for Australia, to the end of 1876, of about 240,000 tons. In 1876 Great Britain produced about 4,700 tons.

Value of copper product.

Coal.

Cordilleras of Eastern Australia.

Coal.—Large coal fields exist along the cordillera of Eastern Australia. A somewhat animated discussion has been carried on regarding their geological position, viz, as to whether they are Paleozoic or Mesozoic, a question thought to bear forcibly upon the probabilities of their extent and quality. The discussion originates in the fact that the greater part of the fossils found in the coal beds are distinct from any recognized in Europe as characteristic of the carboniferous formation. Especially is this the case with plants of the genus *Glossopteris*, which are characteristic of the most valuable portion of the Australian coals. The evidence of the fossil fauna, however, seems to have decided the question in favor of the Paleozoic character of the main deposits. There are also large fields of Mesozoic coal of less but by no means small value.

Fossils peculiar to the anthracite coal beds.

Paleozoic character of the principal beds indicated by the fossil fauna.

Position and extent of the coal fields, New South Wales.

The position of the coal fields is mainly between the cordillera and the coast, and while the gold deposits center in Victoria, the coal fields are most abundantly developed in New South Wales. These coal fields extend northward into Queensland, which unquestionably possesses numerous quantities of coal, hitherto almost untouched. Victoria also possesses coal, chiefly Mesozoic. The carboniferous formation in Victoria is very much broken up, and Mr. Selwyn has referred to the drifted origin of the material forming the Paleozoic coal of Victoria as precluding the probability of the existence of workable coal seams in the Victoria coal measures. In contrast to this condition of things, Mr. Wilkinson remarks upon the frequent occurrence in the coal seams of New South Wales of tree trunks, upright, and evidently undisturbed.

Victoria.

A. R. C. Selwyn.

Tree trunks in situ.

South Australia.

Reports of the discovery of coal beds in South Australia have been circulated from time to time, but have hitherto, so far as I know, proved groundless. Coal has long been known to exist on the west coast of Western Australia, but it is not worked to any considerable extent.

Western Australia.

Principal localities of coal.

The developed coal fields are, then, to all intents and purposes, confined to New South Wales, though Queensland

AUSTRALIA. claims 24,000 square miles of developable coal lands, and
Its mineral resources. Victoria has mined some $60,000 worth of mineral fuel, chiefly at Cape Paterson, up to the end of 1876.

Coal. The following extract from the official catalogue of the exhibit of New South Wales contains valuable information:

New South Wales, Area of carboniferous strata. "The approximate area of the carboniferous strata is estimated at 2 ,950 square miles. The principal coal beds exist along the coast to the north and south of Sidney. The mines just opened are situated in the immediate vicinity of Newcastle, and it is from there that the colony obtains its largest

Lie of the coal. supply. The coal lies near the surface, and the greatest depth to which shafts have yet been sunk is less than 500 feet. In many districts the coal crops out on the face of the

Cost of mining. hills, and can be cheaply got by driving tunnels. The cost of mining is from 3*s.* to 5*s.* 6*d.* per ton.

Quality. Report from Royal Arsenal, Woolwich. "Experiments with the New South Wales coal at the Royal Arsenal, Woolwich, in 1858 and 1859, showed that for steam purposes it was only 7 per cent. inferior to the best Welsh coal, and that, as regards the manufacture of gas, it produces upwards of 9,000 feet per ton, with an illuminating power 24 per cent. greater than the English vari-

Director of Indian Railway Companies. ety known as Whitworth. The government director of the Indian railway companies, in his report to the Secretary of State for India (1868–'69), refers to the quality of Australian coal. He says: 'It has been tried on some of the lines of Western India, and has been well reported on. The expe-

Scinde Railway Company. rience of the locomotive superintendent of the Scinde Com-

Comparison with Welsh coal. pany is that it is equal to Welsh coal in all respects; its evaporative power is nearly equal to Welsh coal, and the consumption per mile is less. The price hitherto has been under that of English-Welsh coal.'

John Mackenzie. "The government examiner of coal fields (Mr. John Mackenzie, F. G. S.) estimates that one seam of coal, after al-

Estimated yield of coal seams. lowing one-third for loss and waste in getting, will yield 84,208,298,667 tons. It has been ascertained by the Rev.

Rev. W. B. Clarke. W. B. Clarke and the examiner of coal fields that there are in the upper coal measures at least 16 seams of coal, each more than 3 feet thick. One seam, whose outcrop is near

W. Keene. Stroud, described by the late Mr. W. Keene, is more than 30 feet thick, as tested by several trial pits sunk on the dip side; and another, whose outcrop is near Wallerawang,

A. Liversidge. recently examined by Archibald Liversidge, esq., professor of geology in the University of Sydney, is 17 feet 6 inches thick. The principal seam from which coal is now being obtained is from 8 to 10 feet thick, the coal being free-burning

AUSTRALIA.

and bituminous—suitable for household, steam, smelting, gas, and blacksmith's purposes.

Its mineral resources.

Coal.

"Mr. R. W. Moody, mining engineer, gives the following description of coal land on the southeastern coast: 'The 5 seams of coal contained in these 600 acres will yield 31,250,000 tons of coal, which will supply a vend of 1,000 per day for over 100 years; and this is independent of the exceedingly rich bed of kerosene-oil shale, which is sufficient to yield 2,000 gallons of refined oil per week for over 72 years. The position of all the seams is so favorably situated, that the coal from each can be got by tunneling into the mountain range, and conveyed to the proposed railway terminus below by self-acting inclined planes.' Writing of the upper coal measures in the western district, the government geologist (C. S. Wilkinson, esq., F. G. S.) says: 'They are 480 feet thick, resting conformably on the marine beds of the lower coal measures, and overlaid by more than 500 feet of Hawksbury sandstone. Eleven seams of coal have been counted in them: the lowest, which is 10 feet thick, lies about 25 feet above the marine beds, and is the same seam worked by Bowenfels, Eskbank, Lithgow Valley, and Vale of Clwydd Collieries. This seam of coal crops out on the surface on the railway line near Bowenfels. It dips at a low angle of 3 to 5 degrees to the northeast, and is therefore easily worked; and as it passes under the vast extent of mountain ranges to the north and east, it will be inexhaustible for generations to come.'"

R. W. Moody.

Coal of the southeastern coast.

Kerosene-oil shale.

C. S. Wilkinson on the upper coal measures.

The following table of the output, home consumption, and mean yearly price of coal in New South Wales is taken from the Annual Report of the Department of Mines for 1876:

Statistics of coal output, consumption, and price.

Coal in New South Wales.

[Output, consumption, and price.]

Years.	Output.	Consumption.	Price.
	Tons.	*Tons.*	*s. d.*
1829–1869	8,110,076	.....	.....
1870	868,564	290,175	7 3.54
1871	898,784	333,355	7 0.47
1872	1,012,426	343,316	7 9.92
1873	1,192,862	419,783	11 1.94
1874	1,304,567	431,587	12 1.37
1875	1,329,729	402,722	12 3.89
1876	1,319,918	451,101	12 2.06
Total	16,036,926	.....	.....

New Zealand.

New Zealand, which seems to form the other edge of a great submerged basin whose western boundary is the East Australian cordillera, possesses immense coal fields,

AUSTRALIA.

Its mineral resources.

the product being, it is stated, even superior to that of New South Wales. Tasmania also is rich in coal, of which a few thousand tons are yearly raised.

Kerosene shale.

Nearly allied to coal is the "kerosene shale," "kerosene-oil cannel coal," or Australian boghead mineral. Boghead coal is of limited local occurrence in Scotland. It consists chiefly of the mineral torbanite, which is nearly allied to cannel coal, and contains, according to Dana, carbon 82.19, hydrogen 11.64, oxygen 6.17. In New South Wales boghead coal and similar bituminous shales are found extensively in association with the coal beds—the boghead sometimes passing over into ordinary coal, sometimes interstratified with it. The official estimate of the area of workable seams of this substance in New South Wales is 660 square miles. The value of boghead and similar coals, both for the manufacture of an oil resembling petroleum and for gas manufacture, is well known. The Hartley shale yields from 150 to 160 gallons of oil per ton, or 18,000 cubic feet of gas, with an illuminating power equal to 40 candles. This is more than is commonly claimed for the Scotch boghead.

New South Wales.

Area of workable seams.

Yield of Hartley shale.

Analysis.

An analysis* of best Hartley shale gave:

Volatile	86.6
Fixed carbon	6.8
Ash	6.6
	100.0

Export.

Competition with American petroleum.

Sales.

The mineral is largely exported for gas-making. The oil competes in Australia with American petroleum, but apparently with no great margin in its favor, as one of the principal sources of supply seems to be worked or not according to the market rate for petroleum. The oil is said to be equal to American petroleum in illuminating power, and superior in safety; and Mr. Reid reports that the oil of the New South Wales Shale and Oil Company "has secured the market to the extent of 300,000 gallons, with increasing demand." From the returns in the mining reports of shale raised by them it is plain that this is their aggregate, not the yearly sale of this company.

The amount of shale obtained in Victoria appears to be insignificant, and in Queensland no attention has as yet been paid to it.

The following table exhibits the progress of the oil-shale industry in New South Wales:

* *Mineral Map and General Statistics of New South Wales.*

Kerosene oil shale.

Years.	Quantity in tons.	Price per ton. £	s.	d.
1865	570	4	2	5.47
1866	2,770	2	18	10.48
1867	4,079	3	14	9.21
1868	16,952	2	17	7.11
1869	7,500	2	10	0
1870	8,580	3	4	3.18
1871	14,700	2	6	3.91
1872	11,040	2	11	11.91
1873	17,850	2	16	6.55
1874	12,100	2	5	1.48
1875	6,197	2	10	2.22
1876	15,998	3	0	0
Total	118,836			
Average		2	14	10.95

Production and price, 1865–1876.

Lead.—Ores of lead, largely argentiferous, are known to exist in Australia, and a few thousand dollars' worth of the metal have been produced in South Australia and Victoria. In New South Wales the plumbiferous area is estimated at 500 square miles, but there are no returns of product and no mines working.

Lead.

As a mineralogical curiosity it may be mentioned that Mr. Smyth states* the occurrence of native lead sometimes studded with gold in deep gold leads at Talbot and Avoca, where they have frequently been seen *in situ* by competent witnesses. The specimens have not been analyzed.

Antimony.—Antimony is met with in various localities in New South Wales. From 1871 to 1874 72 tons of the ore, valued at £897, were treated. In 1875 the production was 142 tons regulus, valued at £5,000. In 1876 40 tons of ore, valued at £140, were raised.

Antimony.

In Victoria there are five antimony smelting works, and £120,000 of antimony had been raised up to the end of 1876.

Gems, though of frequent occurrence in Australia, have thus far paid but poorly, for while many stones of high quality are found in some gold and tin leads, the size is almost always small.

Gems.

Mercury.—Rev. Mr. Clarke writes as follows, in the *Mines and Mineral Statistics of New South Wales*, 1875:

Mercury. Rev. W. B. Clarke.

"Some years since I reported on the occurrence of mercury in this colony, but my expectation of the discovery of a lode of cinnabar has been disappointed. The cinnabar occurs on the Cudgegong in drift lumps and pebbles, and is probably the result of springs, as in California [?]. In New Zealand, and in the neighborhood of the Clarke River, North Queensland, the same ore occurs in a similar way.

Cinnabar.

* *Gold Fields of Victoria*, p. 420.

AUSTRALIA.

Its mineral resources.

Mercury.

About 1841 I received the first sample of quicksilver from the neighborhood of the locality on Carwell Creek, on the Cudgegong, where the cinnabar is found."

Cinnabar and mercury exhibits.

In the Annual Report of the Department of Mines for 1875 it is mentioned that "a cinnabar mine has lately recommenced work" in the district mentioned by Mr. Clarke, which lies near the center of the gold fields; but the report for 1876 passes it over in silence. Samples of ore and quicksilver at Paris made a handsome show, but were accompanied by no information as to the prospects or yield.

Iron.

The *Iron* producing capacities of Australia are unquestionably great, but they are little developed, and do not belong to this report.

V.

RUSSIA.

THE MINING INDUSTRY OF RUSSIA.*

Mineral wealth.

The mineral wealth of Russia is very large, and is based upon a great variety of substances, widely distributed throughout the empire. Its principal metals are gold, platinum, silver, copper, lead, and iron; tin, zinc, nickel, and cobalt are developed to some extent, but are of minor importance. Coal is said to exist in immense quantity in Southern Russia, and its production, already considerable, shows a steady increase during late years. Salt, sulphur, graphite, precious stones, etc., contribute also to the value of the mineral product.

Variety and wide distribution.

Metals.

Coal.

Salt, sulphur, graphite, gems.

The principal sources of the more valuable metals are in the mountain ranges of the Ural and Altai. Copper is not only found in great abundance in the regions just mentioned, but also in the Caucasus, in Finland, and in the Kirghese district. Iron also occurs abundantly, not only in the Ural and in some portions of the Altai, but in some of the central and southern departments of the empire, in Poland, Finland, and in the north. The zinc mines of Poland are counted among the richest of Europe. A single mine in the government of Viborg, Finland, furnishes the entire tin product of Russia, but this is very irregular, and of late years very small.

Precious metals of the Ural and Altai ranges.

Copper.

Iron.

Zinc.

Tin.

The mines of Russia did not assume much importance in the industries of that country until about the beginning of the eighteenth century. Thence until the reign of Elizabeth their development progressed rapidly; but in the latter half of the past century a period of stagnation ensued, which lasted, for reasons partly political and partly economical, for many years. Of late, however, the mining industry has shown in most departments a very considerable ad-

Former importance, followed by stagnation.

Revival of interest.

* The substance of this paper is drawn chiefly from official or semi-official sources, published by the administration of Department of Mines of the Russian Government. Most of the figures are taken from a pamphlet prepared for the occasion of the Paris Exposition, entitled *Tableaux Statistiques de l'Industrie des Mines en Russie en* 1868–1876, *par C. Skalkovsky, ingénieur des mines.* M. Skalkovsky is the secretary of the *Comité Scientifique des Mines*, and the statistics of the department are prepared and published under his supervision.

RUSSIA.

Mineral wealth.

vance. Its progress during the last fifty years is shown by the following table:

Production of metals and minerals, 1830–1875.

Production of sundry metals and minerals in the Russian Empire during years named below.

(Table from page 14 of "Statistics," given in poods.)

Years.	Gold.	Silver.	Platinum.	Copper.
	Poods.	*Poods.*	*Poods.*	*Poods.*
1830	883	1,282	107	238,995
1835	393	1,212	105	240,204
1840	458	1,280	108	280,918
1845	1,307	1,193	1	260,648
1850	1,454	1,068	9	393,618
1855	1,649	1,043	.....	378,618
1860	1,491	1,070	61	315,620
1865	1,576	1,084	139	253,057
1870	2,155	868	119	305,387
1875	1,955	601	94	222,251

Years.	Cast iron.	Coal.	Salt.	Naphtha.
	Poods.	*Poods.*	*Poods.*	*Poods.*
1830	11,169,328	} 600,000	{ 20,920,393	261,000
1835	10,500,146	}	{ 22,500,000	348,956
1840	11,331,510	875,000	27,195,512	237,009
1845	11,432,645	.....	55,476,527	317,166
1850	13,892,325	3,160,000	24,829,009	255,000
1855	15,310,616	2,500,000	32,224,453	.....
1860	18,174,125	8,000,000	26,109,602	.....
1865	16,046,191	12,679,311	29,058,933	554,291
1870	19,503,407	22,163,107	29,013,458	1,704,455
1875	23,255,068	79,444,328	37,591,399	8,174,340

The pood, consisting of 40 Russian lbs., is equal to 16.3808 kilos; 1 pood is equal to 36.1131 lbs. avoirdupois; 1 pood is equal to 526.58 troy ounces; 61.047 poods equal 1,000 kilos = 1 French tonne = 2,204 lbs.; 55.3815 poods equal 2,000 lbs. avoirdupois.

Gold. Production from 1753–1876.

Gold.—The production of gold in Russia, since its commencement in 1753, amounted at the end of 1876 to 67,134 poods, the approximate value of which may be placed at $730,000,000.

The production during recent years is shown in the following table:

Production, 1867–1877.

Production of gold from auriferous deposits during ten years.

Years.	Number of exploitations.	Quantity of sand and mineral washed.	Quantity of gold extracted.	Approximate value of product.
		Poods.	*Poods.*	
1867	878	968,423,325	1,650	$17,958,600
1868	993	1,177,288,244	1,711	18,622,524
1869	1,129	1,054,570,392	2,007	21,841,188
1870	1,208	983,475,095	2,157	23,476,788
1871	978	1,081,518,424	2,400	26,121,600
1872	1,055	1,044,027,585	2,3[illegible]1	25,370,604
1873	1,018	954,648,764	2,025	22,040,100
1874	1,035	937,578,045	2,027	22,061,868
1875	1,092	1,007,293,492	1,996	21,724,[illegible]4
1876	1,130	1,022,543,362	2,051	22,[illegible]75,7[illegible]5
1877	.....	.....	2,430	26,448,120

Mineral wealth. Gold.

Of this product Siberia furnishes from two-thirds to three-fourths, the remainder coming mainly from the departments of Perm and Orenburg, in European Russia, with small contributions from the Kirghese district and Finland. The product of 1876 is credited as follows to the several governments and territories:

Production of gold by governments.

Government.	Location.	Number of exploitations.	Quantity of gold.
			Poods.
Iakoutsk	Siberia	35	628
Iéniseeisk and Irkoutsk	do	336	386
Transbaïkal	do	64	234
Amoor	do	10	172
Tomsk	do	126	107
Littoral	do	3	12
Perm	European Russia	197	177
Orenburg	do	268	110
Sémipalatinsk	Kirghese district	24	12
Akmolinsk	do	6	1
Uleaborg	Finland	9	½

Imperial concessions.

Increased activity in private mines.

Important concessions on the part of the government have recently conferred great advantages upon individual mine owners, and an increased activity in mining operations has been noted as a consequence. Under these new conditions the product of gold in 1877 amounted to 2,430 poods, of which only 155 poods came from the mines of the crown and state; the remaining 2,275 poods came from mines of private individuals; an increase of 437 poods over the product from private mines in 1876. Of the product from private mines in 1877 Eastern Siberia furnished 1,793 poods, Western Siberia 129 poods, and the Ural 353 poods. It is expected, for the same reasons, that gold-mining operations will henceforth become still more active, and the product of the metal will be accordingly greater in the future than in the past.

Placer mining principally.

Nearly all the gold produced in the Russian Empire is obtained from placers. Vein-mining for that metal has not been actively prosecuted until recently, and only in the Ural Mountains. In the foregoing tabular statement of the gold product, the quantity of sand and mineral treated during ten years, as expressed in poods, amounts, in the aggregate, to about 184,000,000 tons of 2,000 pounds avoirdupois, and the corresponding product for ten years is valued at $221,576,472, presuming that the weight of gold given is that of fine metal. This would show a yield per ton of about $1.20. To what extent the product of vein-mining figures in this statement does not appear from the data in hand; but as the product of placers so far exceeds that of vein-mining, it is not likely

Amount of sand and mineral treated.

Its product.

RUSSIA.

Mineral wealth. Gold.

that the latter raises the general average yield per ton very much. Recent official data, referring to the placer-washings of the Ural Mountains, show that in that region in 1875 there were extracted 5,300 kilos of gold from 4,240,000 tonnes of auriferous sand, giving an average per tonne of 1¼ grams. This would correspond to about 20 grains of gold, or something over 80 cents per ton of 2,000 lbs. avoirdupois.

Porcentage of gold in placer washings of the Ural.

Vein-mining in the Ural.

Vein-mining is carried on in the several districts in the Ural, but apparently to a small extent. The district of Bérésowsk, in which gold-bearing quartz veins have been worked for many years, still appears to be the principal locality for this branch of mining. The formation consists of beds of talcose schists, in which occur broad dikes of beresite, a granitic rock containing pyrites and a little mica. The quartz veins traverse the beresitic dikes perpendicularly, rarely, though sometimes, passing beyond the limits of the dikes, which generally have a width of 60 to 80 feet. The quartz veins are not generally large (varying from a small seam to 3 or 4 feet), and the average value of the ore is low, being stated at 2 to 25 grams to the tonne, say about 30 grains, or $1.20 to four-fifths of an ounce troy, or $16 to $17 per ton of 2,000 lbs. avoirdupois. The average value of quartz veins worked in this district during former years is stated at about 13 grams to the tonne, or, say, half an ounce of metal per 2,000 lbs. of ore.

The geological formation.

Percentage of product.

Platinum.

Platinum.—This metal is generally found with the gold of auriferous sands. It rarely occurs by itself, that is, without gold, though such is the case in one or two districts of the Ural, namely, Taguilsk, Goroblagodatsk, and Bisersk. It has not, so far, been found, at least to any considerable extent, in rock *in situ*, although grains of platinum are said to have been observed in the quartz of the mines of Bérésowsk, and the entire product is obtained from placers, that is, sands resulting from the disintegration of the rocks. The deposits of Taguilsk and Bisersk, in which districts platinum is generally found unaccompanied by gold, are described as follows in the official publication of the Department of Mines. Serpentine and peridotite form the bed and the borders of the platiniferous deposit, and fragments of these rocks predominate among those occurring in the sand. Chloritic and talcose schists also occur to some extent in the material comprising the deposits, together with chromic iron and a certain conglomerate of serpentine peridot and chromic iron, with a calcareous cement.

Usually occurs with gold.

Obtained from placers.

Nature of the bed and border rocks of the platiniferous deposit.

From the occurrence of the metal in grain distributed through the fragments of serpentine and peridotite (from

Mineral wealth. Platinum. Serpentine and peridotite the natural gangue of platinum.

which last-named rock the serpentine is believed to have resulted), it is supposed that the platinum originally existed in a state of dissemination throughout these rocks in place prior to their disintegration. This view of the intimate relation of platinum to serpentine is corroborated by the evidence of several examples, as for instance in the district of Miassk, where platinum is found in auriferous sands; the portions most productive in platinum are those which rest upon the serpentine rocks. At the sources of the river Miass, near the Narali Mountains, which are composed of serpentine rocks, the auriferous sands contain considerable platinum; but down the river, in proportion to the disappearance of the serpentine rocks, the quantity of platinum becomes less and less, and finally nothing in places where there are no outcrops of that rock.

Found in grains and nuggets.

The platinum occurs in the form of grains and sometimes in nuggets of greater or less size. The largest nugget so far found weighed about 22 pounds. Platinum is also accompanied by chromic iron, gold, iridium, and iridosonine. The average tenor in metal per tonne of the platiniferous sands is from 6 to 8 grams, or about one-fourth of an ounce troy; sometimes it amounts to an ounce and a third. Since the discovery of the platinum deposits in the district of Nijre-Táguilsk, that is, from 1825 to 1877, the product of that metal there has amounted to 67,500 kilos, or 148,810 lbs.

Annual production of platinum in the Ural.

The average quantity of platinum now annually produced in the districts of the Ural is placed at 1,650 kilos, or 3,360 lbs.

The production of platinum during recent years is given in the following table:

Table of platinum production.

Production of platinum in Russia during recent years.

Years.	Number of exploitations.	Quantity of sands washed.	Quantity of crude metal obtained.
		Poods.	*Poods.*
1867	.....	11, 607, 050	109
1868	.....	18, 070, 650	123
1869	6	13, 678, 700	143
1870	6	9, 609, 150	119
1871	6	10, 440, 650	125
1872	5	8, 252, 900	93
1873	6	7, 620, 300	96
1874	5	9, 954, 800	123
1875	7	9, 091, 000	94
1876	5	10, 370, 100	96
Product for ten years			1, 121
Equivalent in troy ounces			590, 296
Annual average during ten years			59, 030

RUSSIA.

Mineral wealth. Platinum.

The entire product of platinum is furnished from mines of private individuals, and situated in the northern portion of the government of Perm. The refining of the metal was formerly done wholly in the mints of St. Petersburg, but at present, since the removal of the tax, the principal portion is exported in the crude state.

Silver and lead.

Silver and lead.—The following table shows the production of these metals during recent years:

Table of production.

Years.	Number of mines of argentiferous lead.	Quantity of mineral produced.	Number of silver-reducing establishments.	Number of furnaces employed.	Quantity of mineral treated.	Silver produced.	Lead produced.
		Poods.			*Poods.*	*Poods.*	*Poods.*
1867	.....	2,588,404	7	.....	2,774,828	1,106	105,917
1868	29	2,873,486	9	120	3,143,608	1,092	100,225
1869	17	3,083,375	8	123	2,400,717	769	65,092
1870	26	2,116,404	10	130	2,066,792	868	100,654
1871	23	2,177,540	9	130	1,892,636	829	107,964
1872	25	1,886,457	8	110	2,134,119	752	74,662
1873	19	1,883,152	7	120	1,906,425	607	57,606
1874	22	2,065,541	7	119	2,079,868	720	81,150
1875	24	1,580,410	8	103	1,839,826	601	66,060
1876	24	2,096,032	7	111	2,146,728	683	71,278
Product for ten years						8,027	830,608
Equivalent in troy ounces						4,226,857	.....
Equivalent in tons (2,000 pounds)						.....	14,998
Annual average for ten years, ounces						422,686	.....
Annual average for ten years, tons						.....	1,500

Principal source of silver and lead.

The silver and lead product of the year 1876 came chiefly from Siberia, as shown by the following statement:

Department.	Number of metallurgical establishments.	Product of silver.	Product of lead.
		Poods.	*Poods.*
Tomsk, Siberia	5	616	58,499
Transbaïkal, Siberia	1	41	5,077
Terek, Caucasus	1	26	7,701

Extensive deposits of silver ore rare in the Ural.

According to the published data of the Department of Mines there are no very extensive deposits of rich silver ore known at present in the Ural. Occurrence of silver-bearing veins are described in the official papers referred to, but they do not appear to be extensively worked. It will be observed in the above statement, referring to the year 1876, that no part of the silver product is credited to the Ural.

Mineral wealth Copper.

Copper.—The following statement shows the production of copper in Russia during recent years:

Table of copper production.

Years.	Number of mines.	Quantity of mineral raised.	Number of metallurgical establishments.	Number of furnaces.	Quantity of mineral treated.	Production of copper in—	
						Ingots.	Sheets.
		Poods.			*Poods.*	*Poods.*	*Poods.*
1867	.....	7,763,783	.....	.....	7,734,779	257,317	18,259
1868	229	8,097,155	43	190	7,975,706	268,078	30,949
1869	98	8,028,728	39	250	7,975,706	259,803	21,597
1870	71	6,392,622	39	262	7,190,213	308,440	29,642
1871	77	6,222,759	35	247	6,384,154	260,007	21,277
1872	81	5,931,133	32	225	5,848,795	227,376	15,723
1873	64	5,975,690	25	234	5,191,931	223,282	18,971
1874	77	5,205,185	26	258	4,271,723	199,527	22,190
1875	79	5,515,081	25	235	4,877,556	222,769	29,142
1876	71	6,340,543	23	233	5,394,222	236,452	23,341
Product for ten years						2,463,051	.....
Equivalent in tons (2,000 pounds)						44,474	.....
Annual average for ten years						4,447	.....

Sources of Russian copper.

The sources of the copper product of the empire in the year 1876 were as follows:

Government.	Location.	No. of metallurgical establishments.	Production.
			Poods.
Tomsk	Siberia	1	33,645
Perm	European Russia	4	73,702
Oufa	do	4	37,537
Orenburg	do	1	2,408
Viatka	do	1	546
Ekaterinoslav	do	1	135
Elisabethpol	Caucasus	5	52,903
Tiflis	do	2	4,525
Erivane	do	1	900
Akmolinsk	Kirghese	1	28,126
Sémipalatinsk	do	1	739
Nyland	Finland	1	1,287

Tin.

Tin.—The following data concerning the production of tin are drawn from official sources:

Table of tin production.

Years.	Numberofmines.	Quantity of mineral extracted.	Number of metallurgical establishments.	Number of furnaces.	Quantity of tin produced.
		Poods.			*Poods.*
1869	1	213,000	1	2	1,020
1870	1	66,292	1	2	1,030
1871	1	22,909	1	2	475
1872	1	21,445	1	2	263
1873	1	5,936	1	2	130
1874	1	4,596	.....	.....	.....
1875	1	231	.....	.....	.....
Product for five years					2,920
Equivalent in tons of 2,000 pounds avoirdupois					52
Annual average for five years					10.2

RUSSIA.

Mineral wealth.

The whole of the tin product above quoted was furnished from a single mine in the government of Viborg, in Finland.

Cobalt and nickel.

Cobalt and Nickel.—The production of these metals in the Russian Empire during recent years is shown in the following table:

Table of production.

Years.	Number of mines of cobalt.	Number of mines of nickel.	Quantity of cobalt mineral extracted.	Quantity of nickel mineral extracted.	Number of metallurgical establishments producing cobalt.	Number of metallurgical establishments producing nickel.	Quantity of cobalt matte produced.	Quantity of nickel metal produced.	Quantity of nickel oxide produced.
			Poods.	*Poods.*			*Poods.*	*Poods.*	*Poods.*
1867	1	.....	5,220	.....	1	.....	1,306	.....	.....
1868	1	.....	9,000	.....	1	.....	2,447	.....	.....
1869	1	.....	7,715	.....	1	.....	1,560	.....	.....
1870	1	.....	1,249	.....	1	.....	806	.....	.....
1871	1	.....	649	.....	.....	.....	.....	.....	.....
1872	.....	.....	.....	.....	.....	.....	.....	.....	.....
1873	.....	1	.....	2,893	.....	.....	.....	.....	.....
1874	.....	1	28,584	.....	.....	1	.....	26	106
1875	.....	1	22,933	.....	.....	2	.....	126	482
1876	1	1	460	10,350	1	2	188	248	.....

Cobalt ore of the Caucasus.

The ores of cobalt were mined and worked in the department of Elisabethpol, in the Caucasus; those of nickel in the department of Perm, in the Ural.

In the Caucasus the cobalt ore is described as occurring in a contact vein, lying upon a mass of magnetic iron. The inclosing rock of the iron deposit is a diorite, and between the iron and the overlying country rock is a small vein of hard green diorite, in which are small nests, bunches, and stringers of cobalt ore (smaltine), mingled with iron and copper pyrites. The vein was originally worked during several years for copper, the cobalt ores being rejected as worthless. The percentage of cobalt, according to analyses of the ore, varied from 17 to nearly 28 per cent. The ore contained little or no nickel. The vein was worked during several years, but the supply of metal having given out and a considerable sum of money having been expended in ill-directed and fruitless prospecting, the enterprise was abandoned.

Ural ores of nickel.

The ores of nickel in the Ural occur in small veins of quartz, traversing schistose rocks. According to M. Hermann it is an hydrated silicate. It contains 18 per cent. of nickel oxide.

Zinc.—The following table furnishes the official data concerning the production of zinc in the Russian Empire during recent years:

Table of production.

Years.	Number of mines.	Quantity of zinc ore produced.	Number of metallurgical establishments.	Number of furnaces employed.	Quantity of mineral treated.	Quantity of crude metal obtained.
		Poods.		*Poods.*	*Poods.*	*Poods.*
1867	.....	1,150,400*	4	.....	1,971,288*	180,263
1868	10	1,526,928*	4	88	2,111,676*	198,259
1869	.....	2,457,741	4	56	1,668,733	221,328
1870	6	2,666,754	3	128	2,117,318	230,776
1871	6	2,629,477	4	141	1,665,495	166,581
1872	6	4,388,345	3	91	1,459,668	188,144
1873	7	4,394,882	3	91	1,995,627	206,037
1874	9	6,141,105	3	71	2,118,011	251,811
1875	6	4,027,208	3	88	2,318,491	243,280
1876	6	3,749,415	3	127	2,649,848	282,198
Product for ten years						2,168,677
Equivalent in tons of 2,000 pounds						89,158
Annual average for ten years						8,915

*The data from several private establishments are wanting.

Zinc mines of Poland.

The ores of zinc produced in the Russian Empire are mined entirely in Poland. They consist chiefly of carbonates and silicates, associated with brown hematite. They occur mainly in the dolomite beds of the Muschelkalk formation. The principal mines are in the neighborhood of Olkusz and near the boundary line of Silesia. The great zinc-bearing district of Germany is therefore continuous with that of Russia, the division being merely political. The ore occurs in masses and bunches of very variable dimensions, from one to twelve feet wide, and in several instances possessing very much greater thickness. The

Percentage of metal in the ore.

percentage of zinc contained in the ores is generally from 8 to 14 per cent. A large portion of the ore is obtained from open surface workings. Subterranean mining is carried to a considerable extent, but not generally to any great depth on account of the great abundance of water.

Value of zinc product.

The value of the zinc product in 1876, already given in the foregoing table, is stated at about 800,000 rubles, about $600,000.

RUSSIA.

Mineral wealth. Iron.

Iron.—The following table furnishes official data concerning the production of iron in the Russian Empire during recent years:

Table of iron production.

Years.	Number of iron mines.	Quantity of ore extracted.	Number of metallurgical establishments.	Number of blast furnaces.
		Poods.		
1867	.....	36, 849, 139	.....	.....
1868	1, 033	41, 285, 575	187	.....
1869	1, 165	42, 596, 508	155	241
1870	1, 283	48, 703, 156	164	245
1871	1, 180	48, 471, 967	153	244
1872	1, 270	54, 510, 434	150	242
1873	1, 196	55, 047, 471	155	245
1874	1, 387	57, 021, 784	157	247
1875	1, 346	64, 945, 155	150	250
1876	1, 311	61, 735, 785	151	254

Years.	Quantity of ore and slag treated.	Production of metal.		
		In pig.	Sundry forms.	Total metal.
	Poods.	*Poods.*	*Poods.*	*Poods.*
1867	37, 003, 329	14, 642, 724	2, 910, 109	17, 552, 893
1868	43, 048, 318	16, 600, 101	3, 187, 644	19, 727, 745
1869	43, 701, 469	16, 943, 956	3, 159, 908	20, 103, 864
1870	48, 464, 114	18, 557, 412	3, 401, 914	21, 959, 326
1871	48, 329, 281	18, 834, 383	3, 099, 606	21, 932, 989
1872	52, 176, 174	21, 046, 677	3, 328, 956	24, 374, 956
1873	51, 533, 242	19, 970, 066	3, 494, 241	23, 464, 307
1874	51, 049, 066	19, 855, 709	3, 357, 063	23, 212, 772
1875	55, 774, 227	22, 571, 539	3, 489, 784	26, 061, 323
1876	59, 396, 028	23, 302, 057	3, 654, 793	26, 956, 850
Total for ten years				225, 347, 025
Equivalent in tons of 2,000 pounds				4, 068, 994
Annual average for ten years				406, 900

Of the above product of 1876 there were 25,035,453 poods of charcoal iron and 1,021,397 poods of iron made with mineral fuel.

Sources of iron product of 1876.

The iron product of 1876 was derived from the following sources:

Government.	Location.	Number of metallurgical establishments.	Number of blast furnaces.	Product of metal.
				Poods.
Perm	European Russia	43	71	13, 939, 453
Oufa	do	8	13	2, 467, 927
Kalouga	do	14	18	1, 317, 010
Viatka	do	6	12	1, 313, 240
Nijni-Novgorod	do	6	10	1, 234, 065
Ekaterinoslav	do	1	2	1, 021, 397
Orenburg	do	3	6	704, 920
Tambov	do	2	3	238, 024
Riazane	do	3	3	208, 727
Vladimir	do	2	3	184, 760
Olonetz	do	3	3	167, 265
Toula	do	1	1	122, 935
Vilna	do	2	2	84, 777
Orel	do	1	1	62, 726
Volhynie	do	3	3	56, 000
Vologda	do	2	2	12, 131
Radom	Poland	20	28	1, 375, 203
Pétrokov	do	8	10	341, 600

Iron product of 1876, *&c.*—Continued.

Mineral wealth. Iron. Sources of iron product of 1876.

Government.	Location.	Number of metallurgical establishments.	Number of blast furnaces.	Product of metal.
				Poods.
Keltsé	Poland	3	4	173, 920
Knoplo	Finland	6	7	609, 966
Abo	do	3	3	306, 777
Saint Michel	do	3	4	249, 390
Nyland	do	4	4	207, 258
Uleaborg	do	2	2	112, 797
Viborg	do	2	2	91, 892
Irkoutsk	Siberia	1	2	161, 110
Ieniseïsk	do	1	1	87, 997
Transbaïkal	do	1	1	71, 100
Tomsk	do	1	1	30, 888

The principal portion of the iron product, as may be seen in the foregoing table, comes from European Russia and the regions of the Ural Mountains. The prevailing ore of those districts is brown hematite. Magnetite is found in very many localities, but is less extensively worked. Carbonate ores are generally of rare occurrence.

The following table shows the production of wrought iron and steel during recent years:

Table of production of wrought iron and steel.

Years.	Wrought iron in bars, rods, and sundry forms.	Sheet iron of all kinds.	Total wrought iron.	Number of steel furnaces.	Product of forged and cast steel.
	Poods.	*Poods.*	*Poods.*		*Poods.*
1867	.....	.....	11, 457, 645	.....	382, 554
1868	10, 513, 860	3, 173, 099	13, 650, 869	707	568, 885
1869	11, 241, 170	3, 204, 941	14, 446, 411	405	439, 970
1870	11, 971, 459	3, 246, 449	15, 217, 908	495	536, 086
1871	12, 420, 096	3, 086, 317	15, 506, 413	372	442, 241
1872	13, 043, 881	3, 324, 595	16, 368, 476	813	511, 727
1873	12, 026, 281	3, 559, 106	15, 585, 387	472	546, 033
1874	14, 301, 375	3, 073, 745	17, 975, 120	711	469, 718
1875	14, 842, 451	3, 705, 208	18, 547, 659	828	789, 253
1876	12, 853, 076	4, 016, 229	17, 869, 305	681	1, 093, 757

Coal.—The official statistics of mineral fuel furnish the following data concerning its production during recent years:

Coal.

Table of production of coal.

Years.	Number of collieries.	Quantity of bituminous coal produced.	Quantity of anthracite produced.	Quantity of lignite and bituminous schists produced.	Total mineral fuel produced.
		Poods.	*Poods.*	*Poods.*	*Poods.*
1867	.....	19, 613, 026	6, 903, 189	80, 000	26, 596, 215
1868	.....	21, 925, 657	5, 455, 141	150, 141	27, 532, 141
1869	248	24, 871, 106	11, 064, 248	800, 794	36, 736, 148
1870	193	28, 661, 490	13, 017, 371	551, 728	42, 230, 589
1871	327	35, 009, 156	14, 190, 455	1, 454, 941	50, 654, 552
1872	348	45, 076, 324	20, 262, 302	1, 684, 136	67, 022, 742
1873	232	44, 537, 625	24, 704, 675	2, 244, 028	71, 486, 328
1874	303	52, 419, 779	23, 714, 063	2, 679, 295	78, 813, 137
1875	504	76, 551, 713	25, 728, 782	2, 067, 622	104, 348, 067
1876	640	76, 210, 736	33, 274, 467	1, 787, 245	111, 272, 448
1876, tons (2,000 pounds)	.....	1, 376, 105	600, 823	32, 272	2, 009, 200

RUSSIA.

Mineral wealth. Coal. Anthracite, lignite, etc.

The anthracite product in the above table is from the basin of the Donetz. In 1877 the mining of anthracite in the department of Olonetz was commenced. The lignite and bituminous schists come mainly from Southern Russia (Kiev-Elisabethgrad), partly from Poland, and, to a small extent, from the Caucasus and Turkestan.

The product of mineral fuel in 1876 came from the following-named sources:

Sources of mineral fuel, 1876.

Government.	Location.	Poods.
Don	European Russia	41,964,529
Ekaterinoslav	do	16,458,424
Toula	do	13,224,846
Riasane	do	7,452,500
Kiev	do	1,453,478
Perm	do	1,075,567
Esthonie	do	3,000
Pétrokov	Poland	27,068,497
Akmolinsk	Kirghese	872,623
Kouldja	Turkestan	298,932
Siv-Daria	do	50,000
Tomsk	Siberia	294,976
Littoral	do	123,166
Kouban	Caucasus	281,000
Koutaïs	do	52,000

Petroleum.

Petroleum.—The official statistics furnish the following data concerning the production and distillation of petroleum during recent years:

Table of production and distillation of petroleum.

Years.	Number of artesian wells.	Quantity of crude petroleum obtained.	Number of distillation establishments.	Quantity of oil produced.	Quantity of sundry products.
		Poods.		*Poods.*	*Poods.*
1867	.....	998,905	.....	.....	.....
1868	.....	1,753,984	.....	.....	.....
1869	.....	1,635,229	.....	.....	.....
1870	771	1,704,455	.....	.....	.....
1871	697	1,375,523	.....	.....	.....
1872	733	1,535,961	63	518,546	5,076
1873	636	4,176,885	99	1,254,441	41,100
1874	567	5,208,710	110	1,460,596	56,487
1875	.....	8,174,440	106	2,227,704	41,769
1876	.....	.....	.....	.....	.....

Sources of petroleum.

The sources of the above product are almost altogether in the Caucasus, a small proportion coming from Southern Russia and the Kirghese district. In 1877 the production of petroleum and the distillation of mineral oil increased largely, the department of Bokou, in the Caucasus, producing 12 million poods of petroleum and furnishing 4 million poods of mineral oil.

Salt.—The official statistics furnish the following data concerning the production of salt during recent years:

Production of salt, 1867–1876.

	Quantity produced (poods).
1867	44,228,075
1868	36,798,253
1869	39,876,926
1870	36,114,580
1871	28,254,530
1872	39,712,311
1873	50,398,710
1874	46,947,518
1875	37,991,399
1876	42,508,217
Product of 1875, equivalent in tons (2,000 pounds)	767,372

Sources of supply.

The principal portion of the salt product is obtained from saline lakes, about one-third from evaporation, and a small portion from rock-salt. Large deposits of the latter are said to have been recently discovered by borings.

Chromic iron.

Chromic iron.—The official statistics show the following concerning the production of chromic iron during recent years. It is mainly derived from the departments of Perm, Orenburg, and Oufa, in European Russia:

Table of production.

Years.	No. of mines.	Quantity of chromic iron obtained.
		Poods.
1867	2	86,877
1868	5	41,084
1869	2	66,881
1870	9	600,024
1871	6	450,973
1872	7	372,549
1873	9	391,809
1874	6	316,561
1875	8	209,848
1876	4	58,167

Graphite.

Graphite.—The official statistics show the following concerning the production of graphite during recent years. Its chief source is the territory of Semipalatinsk (Kirghese district) and the department of Perm:

Table of production.

Years.	No. of mines.	Product.
		Poods.
1867	1	4,000
1868	2	5,168
1873	1	2,000
1874	1	1,178
1875	4	18,500
1876	3	7,100

Sulphur. Production.

Sulphur.—There is one mine of sulphur and one refinery in Poland (department of Keltze). The product of refined sulphur in 1875 was 31,100 poods; in 1876 the product was

RUSSIA.

Mineral wealth. Sulphur. Statistics.

18,379 poods. Exploitations of sulphur have recently been commenced in the territory of Daguestan, in the Caucasus.

The total number of laborers employed in the mining industry of Russia amounted in 1876 to 285,758.

The horse-power of machines employed in 1876 in the mines and metallurgical works of the empire is stated at 65,717.

Condition of the metallurgical industry of Russia.

The metallurgical industry of Russia is far behind the needs of the country. This remark applies, however, more to the extent of its development than to its methods, and more to the quantity than to the quality of the products.

Within recent years an increased activity in metallurgical industry has been noted. The abolition of serfdom in 1861, the expansion of the system of railways, and the increased use of domestic mineral fuel are among the principal causes that have already promoted and are likely still to advance the development of this branch of industry. The

Liberal policy and administration.

administration of the Department of Mines pursues, on behalf of the government, a very liberal policy. A large corps of engineers are employed constantly in visiting the various sections of the empire, studying and mapping the geology and obtaining all available information tending to promote the development of the mineral resources of the country; and competent men are sent from time to time to visit all portions of Europe and America for the purpose of noting and introducing at home any desired improvements in their methods of work.

Insufficiency of the output for Russian consumption.

The products of mineral industry in Russia are, in many respects, insufficient to supply the demand, and the importation of metals and minerals generally exceeds their export. To what extent this is true is partly indicated by the following statement of imports and exports for the year 1876:

Table of exports and imports.

	Importation.		Exportation.	
	From Europe.	From Asia.	To Europe.	To Asia.
	Poods.	*Poods.*	*Poods.*	*Poods.*
Platinum	.....	.....	66	.....
Copper	357, 644	1, 091	12, 304	6, 622
Lead	1, 354, 229	9, 769	.....	240
Zinc	86, 724	851	.....	105, 107
Cast iron (pig)	2, 965, 032	.....	380	.....
Wrought iron	8, 622, 736	4, 900	858, 546	94, 948
Steel	10, 320, 349	3, 164	4, 330	10, 343
Petroleum	2, 622, 486	3, 193	.....	90, 354
Salt	17, 279, 925	696	2, 919	13, 335
Coal	88, 189, 206	48, 555	34, 475	.....
	Rubles.	*Rubles.*	*Rubles.*	*Rubles.*
Manufactures in metal	26, 825, 336	133, 952	140, 149	293, 719
Machines	27, 154, 897	60, 039	127, 023	.....
Manufactures in gold and silver	510, 387	1, 344	424, 425	1, 650

Among the principal products imported into Russia, according to the foregoing table, are coal, cast iron, wrought iron, steel, copper, and salt. The following statement shows the sources from which those imports were derived in 1876:

Foreign sources of supply.

Countries.	Coal.	Cast iron.	Wrought iron.	Steel and steel rails.	Copper.	Salt.
	Poods.	*Poods.*	*Poods.*	*Poods.*	*Poods.*	*Poods.*
Great Britain	63, 467, 021	1,920, 257	2,987, 677	5, 283, 332	177, 129	4, 690, 004
Germany	22, 606, 138	561, 282	3,469, 066	2, 493, 594	125, 115	7, 024, 501
Austria	1, 054, 384	.....	33, 465	.....	1, 223	.....
France	90, 097	.....	64, 676	79, 316	22, 736	66, 446
Spain	.....	.....	.....	.....	.....	1, 433, 631
Portugal	.....	.....	.....	.....	.....	597, 311
Sweden & Norway	.....	214, 029	39, 784	35, 206	.....	203, 218
Holland	.....	7, 937	1,250, 933	1, 208, 938	1, 368	.....
Belgium	1, 220	.....	.....	.....	.....	.....
Italy	17, 980	48, 308	.....	.....	.....	66, 719
Turkey	415, 232	.....	.....	.....	.....	.....
Roumania	.....	.....	.....	358, 894	.....	87, 394

VI.

SWEDEN.

THE SWEDISH EXHIBIT.

Unequaled show of iron and iron ores.

It was not only in her display of iron and iron ores that Sweden surpassed other countries. The admirable explanatory literature prepared for the occasion under the auspices of the Swedish Government was, on the whole, unequaled. One of the capital volumes distributed in the Swedish pavilion was entitled *Royaume de Suede, Exposé Statistique*, and contains a complete series of papers touching on all the social, industrial, educational, and scientific features of the country, written, too, for the most part, by well-known specialists. It would be a waste of time to attempt any improvement upon the account of the mineral industries of Sweden given in this manual, and the following pages consist essentially of literal translations from it, abbreviated where the original seemed fuller than was needful for the purposes of this report.

Admirable explanatory literature.

The "*Royaume de Suede, Exposé Statistique*," the source of the author's information.

Peculiar geological conditions of Sweden.

Sweden is, so to speak, made up of the extremes of the series of geological formations. The crystalline rocks of the primary formations are, as a rule, immediately covered by the soft beds of the Quartenary epoch, and only a small portion of the intermediate formations are represented. Of these the Silurian covers the greatest area.

Throughout vast regions the country consists of rocks of the primary formations, gneiss alternating with other sedimentary rocks of the same period and even with granite. In Sweden, as in other countries, one grand division of the territory occupied by this rock is composed of red gneiss, another of gray. The gray gneiss extends over most of the eastern portion of the country, the red over the western.

The gneiss formation.

Another division of primary origin, probably later than the preceding, consists of the group called eurite or petrosilex (hälleflinta). Although they cover a relatively insignificant territory, these last rocks are of great industrial value, inasmuch as they contain the most important deposits of iron ores, which do not occur as veins, but in beds or lenticular masses evidently formed at the same time with the inclosing rocks. The same is the case with certain of the deposits of zinc and of copper.

The important eurite group.

Mode of occurrence of iron, zinc, and copper ores.

SWEDEN.

Coal.

So far as is known, coal occurs in Sweden only in the extreme southern province in the Malmöhus district. The geological horizon of the coal beds is not definitely determined, but is commonly referred to the Trias or the Jura. They have, however, been worked at long intervals since the middle of the eighteenth century.

Hogänäs field.

The greater part of the coal extracted has been won in the neighborhood of Hogänäs, in the northern portion of the field. At this point there are two seams. One of these, varying in thickness from six to eighteen inches, is abandoned; the other is, to be sure, some four feet six inches thick, but contains only about seven inches of good coal and thirteen inches of poor coal, the remainder being composed of bituminous shale partings. Below the coal is a bed of fire-clay about five feet in thickness, which is mined with the coal to some extent. The coal called second quality contains 20 per cent. ash, and the third quality no less than 42 per cent. The quantity of coal mined in 1876 was nearly 3,700,000 cubic feet (or, roughly, 80,000 tons). The production has doubled since 1871.

Quality of the seams.

Fire-clay.

Output of coal in 1876.

Active explorations have been going on by boring in the coal district, and to some extent with satisfactory results, several seams, some of them much thicker than that of Hogänäs, having been thus discovered; but usually much of the thickness is shale and clay. The refractory clays are of superior quality, and are extracted in large quantities. Most of the coals are unfit for making coke.

Quality of the coal.

Imports of coal.

The importation of coal and coke, which comes almost exclusively from England, has increased constantly during the last decades. In round numbers the quantity imported was—

In 1860	12,000,000 cubic feet, or, say, 260,000 tons.
In 1870	21,000,000 cubic feet, or, say, 470,000 tons.
In 1876	38,000,000 cubic feet, or, say, 840,000 tons.

Abundance of peat.

Area of the peat marshes.

If Sweden is wretchedly off for coal, it at least has abundance of peat. Recent explorations have proved that the peat marshes cover one-twelfth of the area of the country, and that the average thickness of the peat in these marshes is two meters. For the past few years the high price of coal and "the zeal of a number of patriots" have greatly stimulated the raising and application of this fuel to such an extent that at least eight times as much peat is now extracted as in 1865. No official statistics as to the amount of peat raised exist, but it is believed that at least 450 machines for making peat are at work, and that they will turn out an average of 5,000 tons a year each. Several

Increased application of peat.

Machines and product.

SWEDEN.

machines are mentioned in the report, but that of Eichorn, which makes the peat into balls, as improved by Horn and Thünberg, seems to enjoy special favor.

Peat machines.

United States' interest in the success of the economical applications of peat.

There are districts in the United States where peat is the most plentiful fuel. We have therefore a direct interest in the Swedish efforts to render it a convenient one. No mention is made of the metallurgical application of peat, though it is well known that it is applied, to some extent, in the manufacture of gas for Siemens furnaces.

Use in Siemens furnaces.

Excellent iron ores of Sweden.

It is of course in its admirable iron ores that Sweden possesses its chief mineral wealth. Professor Åkerman contributed a special memoir on the Swedish iron industry to the literature of the Exposition, and by far the greater part of the exhibits related to that metal, with which, however, this report is not concerned.

Copper industry next to that of iron.

Next to iron, copper is the most important metal obtained in Sweden. The most productive copper mines are those of Fahlun and Åtvidaberg, The former is about 120 miles northwest of Stockholm; the latter a few miles nearer, in a southwesterly direction. Copper ores are also obtained in numerous other places in smaller quantities. Lapland has a copper mine at Svappavara, the importance of which has been much exaggerated.

Localities of the copper mines.

Varieties of ores.

The chief ore of copper is chalcopyrite. Variegated copper ore and copper glance are rare. With a view to economizing fuel, which was constantly rising in price, an elaborate ore-dressing establishment was constructed at Fahlun some ten years since, but, in spite of admirable organization, the loss of copper in the ore-dressing operations was too great, and extraction by wet methods was adopted, instead of concentration and smelting. The greater part of the copper is now extracted by chloridizing, roasting, leaching, and precipitation with iron sponge, the copper precipitate being refined in gas furnaces. At Åtvidaberg the old method of smelting is still pursued. The regulus produced by smelting the ore is roasted and reduced to black copper, which is subsequently refined in reverberatory furnaces. The smelting of the ore and calcined regulus is carried out in blast furnaces.

Wet and dry methods.

The present unsual process.

The smelting process.

Production.

Workmen.

In 1876 901 tons of copper and 286 tons of sulphate were produced in Sweden. The number of workmen employed in this industry was 1,455. The production of copper has undergone a sensible diminution in the course of late years. It reached its maximum in 1869, when it amounted to about 2,300. Some 350 to 500 tons commonly remain in the country; the remainder is exported. Copper ore is also exported to England. In 1871 this exportation was in the

Export.

neighborhood of 1,500 tons, but had sunk to half this amount in 1876.

Copper

Copper is worked up in part in the smelting works and in special rolling mills, partly by coppersmiths in town and country, and in part, and that on a large scale, by the great machine shops of the country. The manufacture of apparatus for the distillation of spirits is one of the principal branches of the Swedish copper industry.

Principal application of the copper.

Gold.

Gold is extracted at present only from the copper pyrites of Fahlun, and to the extent of some half-dozen kilos per year.

Lead and silver.

Lead and Silver.—The principal silver mine of Sweden is the old and famous one at Sala. Its production is insignificant now in comparison with its former yield, and in 1876 was only 798 kilos. All the silver is produced from lead ores, and of lead as well as of silver only a very small quantity is now produced—some 300 tons.

Nickel.

Nickel.—Nickeliferous ores are of frequent occurrence in Sweden, but comparatively seldom in paying quantities. The principal mines are at Kleva, in the province of Jönköping, and at Sägmyra, in Dalecarlia. The product consists of an alloy of nickel, more or less rich in copper, of which somewhat less than a ton was produced in 1876. At Tünaberg about a thousand pounds of clean cobalt ore was extracted in the same year.

Zinc.

Zinc occurs only as a blende, of which there are several mines. The most important is that of Ammeberg, which lies between the great lakes Werner and Wetter. It belongs to the famous Belgian company *La Vielle Montagne*. The product of this mine was about 1,300 tons of ore in 1860, but since 1865 the output has been from 25,000 to 30,000 tons. Adding the product of mines in the provinces of Örebro and Kopparberg, the total production for 1876 was 35,523 tons. The ore is concentrated by roasting, leaching, and dressing, and is thus exported. No metallic zinc is produced in Sweden. Manganese, iron pyrites, for sulphuric acid manufacture, etc., and graphite are mined to a small extent.

Mine of Ammeberg.

Production of zinc in 1876.

Metal working in its various branches is carried on with some activity for the supply of the home market. There are four brass works in the country, several German-silver factories, silver-plating establishments, and the like.

Metal-working establishments.

The greater portion of the surface of Sweden is composed of hard and compact rocks belonging to primitive formations, such as gneiss, eurite, granite, etc., and it is in these rocks that most of the ore deposits are found. In consequence of

The primitive character of the Swedish rocks.

SWEDEN.

this fact, prospecting by boring has not been so much practiced in Sweden as in some other countries. The position and extension of deposits of iron ore have been for a century, and are still, investigated by the magnetic needle. It is certainly incorrect to speak of this method of prospecting for magnetic ores of iron, as the Swedish commissioners do, as *presque inconnu à l'étranger*. Professor Thalén, the well-known physicist, has lately mounted the needle as an instrument of precision, and has shown how, by a considerable number of observations on the deflections of the needle above a deposit of iron ore, the positive and negative poles of the magnetic mass can be determined. Between these points lies the greater portion of the ore body.

Prospecting by boring but little practiced.

Investigation by the magnetic needle.

Boring apparatus.

The apparatus most used for boring, where this method is practicable, is that of Mortensen. The diamond drill and the Chinese rope-drill have also been applied. For drilling short holes many machines have been tried. The "Iron Bureau" (*Jern Kontoret*) had a series of competitive trials executed at its expense with the machines of Burleigh, Schram, Rand, Ingersoll, and Cederblom. Our authority reports: "The result of all these trials has been that machine drilling, far from being cheaper than hand work, cost much more in most cases, a circumstance due principally to the astonishing dexterity of our miners." It would be interesting to know something of the size of the openings where the trials were made, etc., in order to gage the extent of our astonishment.

Diamond and other machine drills.

Comparison of machine and hand drilling.

Swedish mining machinery offers no special points of interest. Access is obtained even to the mines at Fahlun (1,200 feet) and Sala (1,100 feet) by ladders only. Little trouble is experienced with water, and pumping and hoisting are commonly effected by power derived from water-wheels, for water-power is more generally available in Sweden than in almost any other country.

Miners' ladders.

Drainage and hoisting works.

VII.

NORWAY.

THE NORWEGIAN EXHIBIT.

The Scandinavian peninsula is a geological unit, and what has been said of the geology of Sweden is, for the most part, equally true of Norway. The deposits of lignite in the southern province of Sweden do not extend into Norway, and the kingdom is practically without coal or lignite. Even the formations where such might be looked for are confined to the portion of the country lying within the Arctic Circle.

Absence of coal and lignite.

The fundamental rocks of Norway are assigned* by Norwegian geologists to the Azoic epoch, in which is included what Hunt and other American geologists call the Eozoic or Archæan, as well as the earlier gneiss. The close of the Archæan period in Norway was marked by eruptions of granite, forming in part ranges of hills, in part irregular masses. These granites are frequently accompanied by *gabbro*,† and possess great importance with reference to the deposits of ore.

As to the geological character of the rocks of Norway.

Immediately after the great topographical changes produced by the eruptions of granite, and possibly while they were still going on, began the deposition of the Taconic beds.‡ These beds rest unconformably on the older strata and are three in number. The second has been identified as corresponding to the Potsdam epoch in the United States. The Taconic beds cover a very large proportion of the area of Norway.

Intrusions and depositions.

Important occurrences of eruptive rock are also met with which are referred to the close of the Taconic era. The eruptive rock is mainly gabbro, but granite, syenite, and diorite of seemingly eruptive character are also referred to the same period.

Eruptive rocks.

The Silurian and Devonian formations occur mainly in two considerable areas, the one at and north of Christiania,

Silurian and Devonian formations.

* *Le Royaume de Norvége et le Peuple Norvégien*, par le Dr. O. G. Broch, p. 105.

† A variety of greenstone; equivalent to the *Fr. Euphotide.*

‡ The Taconic system of Emmons is nearly synonymous with the Lower and Middle Cambrian of Sedgwick and others.

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the other in nearly the northernmost portion of the country. Eruptive rocks are assigned to periods during the Silurian and succeeding the Devonian.

Periods of eruptive rocks.

Four outbursts of plutonic rock are, then, recognized in Norway: An Ante-Taconic, a Post-Taconic, a Silurian eruption, and one in Post-Devonian times.

Absence of certain formations.

Throughout Southern Norway all the formations from the Devonian to the Post-Tertiary are wanting.

Coal seams.

On the little island of Andoe, off the northwest coast of Norway, occur coal seams determined by Dahll as Jurassic. These seams are thin, varying from 4 to 20 inches,* and are at present of no practical value. In Finmark, the northernmost province of Norway, there are also beds of graphite, supposed to be of Carboniferous origin.

Graphite.

The connection between the ore deposits of Norway and its geological structure is interesting. Norway is the home of the *Fahlbands*, or the impregnated zones of rock, and these deposits are almost uniformly at or near the contact between the eruptive crystalline rocks and the more or less metamorphic sedimentary strata. Thus to the west and northwest of Kongsberg, at the limits of an Ante-Taconic granite area, occur masses of gabbro. Near the gabbro the adjoining "Azoic" rock contains the famous deposits of native silver and silver ores—veins in *Fahlbands*. The cobalt deposits of Snarum and Modum and the nickel deposits of Ringerike are of the same character. At Ekersund titanic iron ore is found under similar conditions.

The *Fahlbands*.

The positions of their occurrence.

Metallic deposits in the *Fahlbands*.

Occurrence of iron and copper ores,

Ores, especially those of copper and of iron, frequently occur at the edge of the Ante-Taconic granite. This is the case with the celebrated iron-ore deposits of Naes, and with copper mines at several points in Telemark and in Saetersdal. The Post-Taconic eruptive rocks, especially the gabbro, are similarly accompanied by ore deposits, particularly of chrome iron, copper, and nickel. The well-known copper deposit at Roeros or Roeraas, in Trondhjem, is of this character. The Silurian and Post-Devonian outbursts of plutonic rocks do not appear to have been accompanied by the deposition of ores; it is, however, from these later occurrences, especially at Grefvenås, near Christiania, that the granite so valuable for ornamental and monumental purposes is quarried.

and nickel.

Auriferous river-beds.

All the considerable rivers of the extreme north of Norway are auriferous. The gold is found in small scales in the river-beds and in the coarse secondary gravel deposits form-

*J. Marcou, *Carte Geolog. de la Terre*, p. 76. Letter from Mr. T. Dahll.

ing the high banks between which these rivers run. From the description given, it seems not impossible that these deposits might be suitable for hydraulic mining were they situated in a more genial latitude.

Auriferous river-beds.

Norway, though a remarkable mineral country, cannot be called a rich one, for the value of the products of the mines and smelting works is not much more than half that of the crude and bar metal consumed in the kingdom, as is shown in the following table:

Inadequacy of the native supply of metals.

Mean annual value of the Norwegian metal trade from 1871 *to* 1875.

Statistics of production, import, and export.

Value of products of mines and smelting works	$1,521,400
Value of crude and bar metal exported	554,932
Value of crude and bar metal retained	966,468
Value of crude and bar metal imported	1,645,756
Value of crude and bar metal consumed	2,612,224

Decline of the mining industry.

The mining industry of Norway appears to be declining in some important respects. The value of the silver and of the iron produced annually since 1870 was little more than half as great as it was between 1850 and 1855. The copper product has remained very nearly constant. On the other hand, the amount and value of the nickel and the pyrites mines has increased rapidly since 1860, bringing the total value of the mining industry to a slightly higher point than it reached twenty years ago.

Increase in the nickel and pyrites product.

The following tables from Dr. Broch's volume exhibit the commercial relations of the Norwegian mining industry:

Product of the Norwegian mines.

Product of the Norwegian mines.

	Mean for the years—		
	1861–'65.	1866–'70.	1871–'75.
Silver ore ..... tons*	1,900	2,000	2,190
Copper ore ..... do	13,330	16,680	16,610
Pyrites ..... do	13,190	65,860	72,285
Iron ore ..... do	24,495	20,235	28,235
Cobalt ore ..... do	5,875	2,290	3,115
Chromium ore ..... do	600	10	90
Nickel ore ..... do	3,540	4,560	18,580
Zinc and lead ore ..... do	.....	3,000	600

*Tons of 1,000 kilos, or 2,205 pounds avoirdupois.

Product of the Norwegian smelting works.

Product of the Norwegian smelting works.

	Mean for the years—		
	1861–'65.	1866–'70.	1871–'75.
Silver.....tons..	3.3	3.6	3.6
Copper.....do...	522.8	512.9	563.6
Copper sulphate.....do...	3.4	12.9	8.0
Iron.....do...	8,850.0	2,605.0	1,680.0
Cobalt.....do...	16.2	3.2	35.1
Arsenic.....do...	3.2	0.6	6.8
Nickel.....do...	12.6	39.5	110.5

Value of the product of mines and works.

Value of the products of mines and works.

	Mean for the years—		
	1861–'65.	1866–'70.	1871–'75.
Silver.....francs..	720,000	780,000	760,000
Copper.....do...	1,170,000	1,200,000	1,400,000
Pyrites.....do...	880,000	1,970,000	2,320,000
Iron.....do...	1,680,000	1,010,000	890,000
Cobalt.....do...	110,000	60,000	150,000
Chromium.....do...	200,000	.....	7,000
Nickel.....do...	140,000	310,000	2,050,000
Zinc and lead.....do...	.....	150,000	80,000
Total.....do...	4,400,000	5,480,000	7,607,000
Total in dollars.....	880,000	1,096,000	1,521,400

Kongsberg silver mines.

A considerable number of Norwegian mines exhibited at Paris. The most noted of them all is Kongsberg, so famous for its enormous masses of native silver, and so peculiar from the fact that this silver contains mercury. The Kongsberg mine was discovered in 1623, and opened the next year, under royal auspices, by miners from Saxony.* In 1630 a mass of native silver weighing 400 marks, or 93.5 kilos, was discovered. A large number of mines were opened up, and the number of workmen employed rose to about 4,000. The mines were worked steadily up to the year 1805; but not having paid running expenses after 1770, were shut down. The total production up to 1805 was 561,150 kilos of fine silver.

Discovery in 1623.

Product up to 1805.

Reopening in 1815.

In 1815† the mines were again opened by the Government of the United Kingdom of Norway and Sweden, but upon a smaller scale. Only four mines are now in operation, viz, the Armen (Poor Man's Mine), Kongens (King's Mine), Gottes Hülfe (God's Help), Has Sachsen (House of Saxony). Of these the first is the deepest, and reaches a depth of about 1,900 feet. The hoisting in these mines is performed

* Brückmann, *Magnalia Dei.*, etc., p. 860.

† The *Catalogue of the Norwegian Exhibit*, from which most of this information is taken, reads 1875, a misprint.

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by water-power, and the drainage and transportation in part by tunnels.

Kongsberg silver mines.

The ore is sorted and dressed by machinery. The native silver, containing 87 to 90 per cent. of the metal, is refined by a single operation in a refining furnace, which brings it up to 0.998 or 0.999 fine. The other concentrations are smelted with pyrites and rich slags, and the regulus is resilverized by lead, which is refined.

Treatment of the ore.

The King's Mine (1,870 feet deep) has been the most productive, and large masses of native silver and of argentite are often found there. In 1832 a single mass of silver weighing 500 kilos (worth, say, $20,000) was found; and in 1867 another of the same size was discovered.

Large masses of native silver.

The present production is from 4,000 to 4,500 kilos of silver yearly, besides 10 tons of copper derived from the pyrites added in the smelting process.

Present production.

The Kongsberg mines exhibited interesting specimens illustrating the ore deposits, the ores and native silver, and maps of the workings.

Exhibit of the ores, metal and workings.

Various nickel mines also exhibited. The metal is not purified in Norway, but reduced to an alloy of nickel and copper and other foreign substances, and exported to England or Germany for farther manipulation.

Nickel.

VIII.

BELGIUM.

THE BELGIAN EXHIBIT.

Great mineral wealth.

The territory of Belgium comprises about 11,372 square miles and contains a population of 5,300,000 inhabitants. Taking into account its limited area, it is, in respect to mineral wealth, one of the most favored countries of the world.

Variety of mineral productions.

In fact, it may be said that, excepting certain metals, precious stones, and some other substances of but little real use, the country furnishes all the materials necessary to satisfy the wants of mankind. The extraction of these substances is facilitated also by their mode of occurrence in

Favorable geological conditions.

the rocks containing them. The geology of the country is highly varied, nearly all the important and economically valuable formations being represented among the rocks outcropping at the surface; and it is partly to this circumstance that the great diversity of industries developed in the land is to be attributed.

Coal, iron, lead, and zinc, the principal mineral resources.

Coal, iron, lead, and zinc are of chief importance among the mineral resources of Belgium; but, besides these, there is a great variety of other valuable substances, the products of the earth, such as materials used in construction, in agriculture, in the arts and manufactures, which form the basis of many varied and extensive branches of industry.

Cornet on the "Mineral Industry of Belgium."

The following table, which is an abridgment of one presented by M. Cornet, in his paper on the Mineral Industry of Belgium, shows the different useful substances occurring in Belgium, grouped according to the geological formation in which they are found:

Formations and their yield.

Modern formation	Peat.	
	Materials for bricks.	
	Gravel for road metal.	
	Iron ore.	
Quaternary	Materials for bricks, Sand.	Construction.
	Gravel for road metal.	
	Iron ore.	
Tertiary	Iron ore.	
	Sandstone for rubble, dressed stone for building, pavements, refractory stones, etc.	
	Sands (construction, ballast, molding, glass manufacture, and other uses).	

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Formations and their yield.

Tertiary	Clays for tiles, drainage pipes, pavements, bricks, etc. Concretionary limestones for Roman cement. Limestones (dressed stone for building). Marls for fertilizers.
Cretaceous	Limestones for building. Phosphate of lime (fertilizer). Chalk for manufacture of lime, carbonic acid, etc. Silex for pottery and road metal. Marl. Fuller's-earth. Clays for sundry uses. Sands. Iron ore.
Jurassic	Limestones for sundry uses. Iron ores. Fertilizers. Sandstones.
Triassic	Marls. Hydraulic limestones.
Carboniferous	Coal. Sandstones for various uses. Schists producing alum. Silicious sandstones for road metal. Limestones and Dolomites for various uses. Lead ores. Iron pyrites. Zinc ores. Barytes.
Devonian	Limestones and Dolomites for various uses. Sandstones. Iron ores. Zinc ores. Iron pyrites. Barytes. Slates. Whetstones. Grinding stones.
Silurian and Cambrian	Slates. Whetstones. Sandstones for various uses. Cut stones for construction. Sands and minerals used in pottery. Manganese. Manganiferous iron ore.

Coal.

The region of its occurrence.

Coal.—A broad and deep valley, formed by a depression of the Carboniferous limestone, traverses Belgium from the southwest to the northeast, passing by Quiévrain, Mons, Charleroi, Namur, and Liège. The rocks of this valley consist of the coal-bearing formations, and along its line from the French to the German frontier active coal-mining operations are in progress.

Depth of the coal-bearing strata.

The depth of the coal-bearing strata, considered with reference to sea-level, varies very much at different points

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along the line of the valley. In the near neighborhood of Namur, in the central line or axis of the basin, the lower members of the coal-bearing formation are exposed at the surface at a height of 650 feet above the sea. From that point the formation is inclined both to the east and the west, reaching its greatest depth or thickness near the town of Mons on the west and near Liège on the east. Beneath the town of Mons the depth of the coal basin is 2,270 meters (7,445 feet) below sea-level. At Boussu, a little farther west, its depth is probably 325 feet greater; and, as the altitude of that locality is about 100 feet above the sea, a vertical shaft sunk at that point would only reach the lowest coal-bearing rocks at the great depth of 7,872 feet. Near Liège the thickness of the coal-bearing formation is also very considerable, and probably exceeds 4,600 feet.

Inclination, depth, and thickness of the coal measures.

The two coal-bearing basins.

By reason of this inclination or dip of the coal formation in opposite directions to the east and the west from the neighborhood of Namur, the coal fields, considered geographically, are divided into two parts—the basin of Liège at the east and the basin of Hainaut at the west. The last named, which is the more important for the production of coal, includes in the mining district of Charleroi that part of the basin which is situated in the province of Namur.

Relation of the number of coal seams to the thickness of the Carboniferous formation.

The number of coal seams occurring at any part of the coal basin is generally proportionate to the thickness of the Carboniferous formation at the part considered. They are accordingly less numerous in the province of Namur and increase in number, both to the eastward and the westward, in approaching the districts of Liége or Mons. In the western basin, where the coal formation has its greatest known thickness, there are from 130 to 160 coal seams, of which about two-thirds are workable. According to André Dumont there are 85 coal seams in the province of Liège.

The formations overlying the coal measures.

In the provinces of Liège and Namur, as well as in a portion of the province of Hainaut, the coal formation is covered only by the alluvial formations of the Meuse and the Sambre or by inconsiderable thicknesses of the Cretaceous, Tertiary, or Quaternary beds. The sinking of mining shafts in those localities is consequently attended by no very serious difficulties. West of Fontaine l'Evêque, in the district of Hainaut, the deposits overlying the coal formation attain a constantly increasing thickness, reaching a depth of 1,000 to 1,300 feet between the town of Mons and the French frontier. To pass through these formations, which contain inexhaustible sources of water and quicksand, some of the

Depth of overlying deposits in the district of Hainaut.

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most important and extensive works known in the records of mining industry have been undertaken.

Rocks associated with the coal.

The rocks of the Carboniferous formation most intimately associated with the coal are schists and sandstones. The former are the prevailing rocks. Generally the coal seam is intercalated between two strata of schist; occasionally the coal is overlaid with sandstone, and sometimes, though rarely, the sandstone forms the floor on which the coal reposes. The relation of the strata to each other is usually as follows:

Schist.
Coal.
Schist.
Sandstone.

Relation of the thickness of coal seams to that of the whole formation.

In general the coal forms less than a one-thirtieth part of the whole material composing the formation.

Thickness of seams.

The thickness of the coal seams varies from a few inches to 8 or 10 feet, but generally the workable seams are from 20 inches to 4 feet thick. Those less than 15 inches are seldom if ever exploited. The workable seams are rarely composed of coal unmixed with other material, but are frequently divided by thin layers of carbonaceous schist.

The following is one of a number of examples representing a vein of average character:

Example.

	Inches.
Carbonaceous schist	2
Coal	15.5
Carbonaceous schist	6
Coal	18.75
Schist	2
	44.45

Length of Belgian coal basin.

The length of the Belgian coal basin, measured along its central axis, from the French to the German frontier is 170 kilometers, or about 106 miles. Its width, measuring its exposure at the surface is variable, as shown by sections at various points named below:

Width.

	Miles.
At the west of Mons, about	8
At the meridian of Charleroi, about	9½
At the meridian of Namur, about	2
At Huy, about	2
At Seraing, about	5
East of Liège	11

Area of workable coal field.

The entire area of the surface exposure of the coal formation of real economic value in Belgium is estimated at 532 square miles, of which total 316 square miles are in the

BELGIUM.

basin of Mons and 216 square miles are in the basin of Liège.

Early use of coal.

The exploitation of coal in Belgium commenced at a very early age. Indeed, notwithstanding the probability that mineral fuel was known and used in China a thousand years before Christ, one of the existing legends concerning the history of coal refers its first discovery to the neighborhood of Liège, in the year 1198, by a smith named Hullos, from whom the name of the mineral *houille* was derived. The coal-mining industry began to assume importance in Belgium in the last century and has since then been almost constantly growing, promoted as it has been by the use of steam power, first for drainage and later for extraction of coal.

Liège, 1198.

Statistical data commence in 1836.

The complete statistical data concerning the coal industry of Belgium go back only to the year 1836. At that time the annual production of the country already exceeded 3,000,000 tonnes. The annual increase since that period appears in the following table, which shows the production of the several provinces traversed by the coal basin, together with the total production of the country. From 1836 to 1873 the production of coal in Belgium was multiplied fivefold. In the last-named year it reached its maximum. Its diminution since that date is attributed to the general depression of all industry, not only in Belgium but in neighboring countries.

Coal industry of Belgium.

Table of production of coal: 1836–1876.

Years.	Production of coal in Belgium in the provinces of—				Total.
	Hainaut.	Namur.	Liège.	Luxembourg.	
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
1836	2,349,374	97,174	627,916	.....	3,074,464
1837	2,469,605	92,473	666,729	.....	3,228,807
1838	2,405,909	103,954	740,408	.....	3,260,271
1839	2,599,011	124,397	755,753	.....	3,479,161
1840	2,951,781	125,054	853,124	4	3,929,963
1841	2,968,875	122,777	935,854	261	4,027,767
1842	3,059,183	134,451	946,902	927	4,141,463
1843	2,874,453	140,698	966,365	758	3,982,274
1844	3,290,728	134,008	1,019,908	896	4,445,240
1845	3,670,486	161,872	1,086,045	753	4,919,156
1846	3,798,335	159,864	1,078,380	823	5,037,402
1847	4,201,531	158,807	1,303,905	707	5,664,450
1848	3,651,712	157,264	1,050,170	518	4,862,694
1849	4,018,195	169,688	1,063,453	507	5,251,843
1850	4,420,701	177,306	1,122,225	296	5,820,588
1851	4,753,186	187,857	1,292,099	.....	6,233,517
1852	5,234,646	182,578	1,377,906	.....	6,795,254
1853	5,482,771	185,504	1,503,275	.....	7,172,687
1854	6,154,860	209,990	1,582,790	.....	7,947,742
1855	6,458,416	230,861	1,720,053	.....	8,409,330
1856	6,219,132	218,609	1,774,678	.....	8,212,419
1857	6,441,182	201,804	1,740,916	.....	8,383,902
1858	6,885,011	217,774	1,852,929	.....	8,925,714
1859	7,099,326	220,850	1,840,526	.....	9,160,702
1860	7,507,720	204,528	1,898,647	.....	9,610,895
1861	7,935,645	243,061	1,878,457	.....	10,057,163

(Continued.)

Coal industry of Belgium—Continued.

Table of production of coal: 1836–1876 (from former page.)

Years.	Production of coal in Belgium in the province of—				Total.
	Hainaut.	Namur.	Liège.	Luxembourg.	
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
1862	7, 795, 170	246, 500	1, 893, 975	....	9, 935, 645
1863	8, 101, 102	255, 067	1, 998, 561	.....	10, 345, 330
1864	8, 670, 372	266, 235	2, 221, 729	.....	11, 158, 336
1865	9, 206, 058	305, 734	2, 328, 911	.....	11, 840, 703
1866	9, 851, 424	358, 687	2, 564, 551	.....	12, 774, 662
1867	9, 595, 289	389, 586	2, 770, 956	.....	12, 755, 822
1868	9, 398, 550	310, 969	2, 589, 070	.....	12, 298, 589
1869	9, 840 530	303, 638	2, 798, 726	.....	12, 942, 894
1870	10, 196, 530	338, 407	3, 162, 181	.....	13, 697, 118
1871	10, 037, 230	350, 389	3, 345, 537	.....	13, 733, 176
1872	11, 616, 166	389, 688	3, 658, 094	.....	15, 658, 948
1873	11, 652, 953	450, 870	3, 674, 578	.....	15, 778, 401
1874	10, 698, 130	440, 124	3, 530, 775	....	14, 669, 029
1875	10, 968, 175	491, 365	3, 551, 791	.....	15, 011, 331
1876	10, 486, 660	474, 975	3, 367, 943	....	14, 329, 578

Table of population. Extraction, and consumption of coal: 1836–1876.

Years.	Population of Belgium.	Quantity of coal—				Average consumption per inhabitant.
		Extracted.	Imported.	Exported.	Consumed.	
		Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
1836	.....	3, 074, 464	22, 447	773, 612	2, 323, 299	.....
1837	.....	3, 228, 807	28, 415	789, 083	2, 468, 139	.....
1838	3, 972, 943	3, 230, 271	34, 703	775, 534	2, 519, 440	0. 634
1839	4, 013, 052	3, 470, 101	28, 363	745, 569	2, 761, 955	0. 688
1840	4, 054, 352	3, 929, 963	30, 424	779, 473	3, 180, 914	0. 784
1841	4, 092, 557	4, 027, 767	28, 962	1, 015, 194	3, 041, 535	0. 743
1842	4, 113, 775	4, 141, 463	35, 192	1, 014, 716	3, 161, 939	0. 763
1843	4, 194, 093	3, 982, 274	30, 855	1, 086, 321	2, 920, 808	0. 699
1844	4, 258, 426	4, 445, 240	11, 449	1, 245, 399	3, 211, 290	0. 754
1845	4, 290, 316	4, 910, 156	9, 348	1, 543, 472	3, 385, 032	0. 790
1846	4, 335, 319	5, 037, 402	11, 088	1, 355, 833	3, 692, 657	0. 852
1847	4, 345, 014	5, 604, 450	9, 930	1, 827, 105	3, 847, 275	0. 885
1848	4, 359, 090	4, 862, 694	9, 557	1, 460, 570	3, 411, 681	0. 783
1849	4, 398, 016	5, 251, 843	10, 909	1, 664, 973	3, 597, 839	0. 811
1850	4, 469, 310	5, 820, 588	9, 397	1, 987, 184	3, 842, 801	0. 859
1851	4, 490, 113	6, 233, 517	9, 908	2, 057, 050	4, 186, 465	0. 932
1852	4, 502, 912	6, 795, 254	8, 102	1, 103, 546	4, 699, 810	1. 043
1853	4, 548, 507	7, 172, 687	12, 845	2, 331, 595	4, 853, 937	1. 067
1854	4, 584, 032	7, 947, 742	53, 082	2, 625, 958	5, 374, 866	1. 172
1855	4, 529, 461	8, 409, 330	68, 578	2, 974, 349	5, 503, 559	1. 215
1856	4, 530, 228	8, 212, 409	88, 709	2, 866, 137	5, 434, 991	1. 197
1857	4, 590, 217	8, 383, 002	146, 069	2, 877, 012	5, 642, 959	1. 229
1858	4, 623, 089	8, 925, 714	107, 605	3, 091, 316	5, 942, 003	1. 285
1859	4, 671, 187	9, 160, 702	110, 069	3, 145, 235	6, 125, 536	1. 311
1860	4, 731, 957	9, 610, 895	97, 009	3, 450, 306	6, 257, 598	1. 322
1861	4, 782, 255	10, 057, 163	92, 771	3, 379, 409	6, 770, 525	1. 415
1862	4, 836, 566	9, 035, 645	78, 817	3, 200, 595	6, 723, 867	1. 390
1863	4, 893, 021	10, 345, 330	72, 907	3, 329, 507	7, 088, 730	1. 448
1864	4, 940, 570	11, 158, 336	68, 224	4, 011, 197	7, 215, 363	1. 460
1865	4, 984, 451	11, 840, 703	76, 044	4, 404, 488	7, 512, 259	1. 505
1866	4, 829, 320	12, 774, 662	187, 306	4, 865, 894	8, 096, 074	1. 676
1867	4, 897, 902	12, 755, 822	461, 180	4, 400, 364	8, 816, 588	1. 800
1868	4, 961, 644	12, 298, 589	247, 749	4, 659, 000	7, 887, 338	1. 589
1869	5, 021, 336	12, 942, 894	230, 342	4, 606, 946	8, 575, 290	1. 707
1870	5, 087, 105	13, 697, 118	235, 250	3, 964, 844	9, 967, 524	1. 959
1871	5, 113, 680	13, 733, 176	205, 838	4, 368, 287	9, 570, 727	1. 871
1872	5, 175, 037	15, 658, 948	221, 890	5, 630, 197	10, 250, 631	1. 980
1873	5, 215, 823	15, 778, 401	683, 373	5, 286, 190	11, 175, 584	2. 142
1874	5, 265, 634	14, 669, 029	470, 514	4, 602, 896	10, 476, 647	1. 989
1875	5, 308, 217	15, 011, 331	720, 534	4, 965, 227	10, 766, 638	2. 028
1876	5, 336, 185	14, 329, 578	826, 131	4, 032, 097	10, 523, 612	1. 972

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Considerations from the foregoing tables.

According to the second of the foregoing tables, which shows for a series of years the population of Belgium, the quantities of coal produced, imported, exported, and consumed, and the amount consumed per each inhabitant, it appears that the consumption of coal, which in the earlier years considered did not exceed two and a half million tonnes, or about 600 kilos (1,320 lbs.), per inhabitant, increased in thirty-six years to more than eleven million tonnes, or 4,712 lbs. per inhabitant.

Yield per hectare.

If the coal production of 1873 (the most productive year) had been furnished in equal proportions from all parts of the surface of the coal basin, each hectare (2.47 acres) would have yielded 115 tonnes of coal. The yield per hectare is, of course, not equal, some portions yielding much more than others. In one of the concessions (Bonne Espérance) near Charleroi each hectare of coal land furnished, on the average from 2,500 to 3,000 tonnes of coal annually.

The foregoing tables give an idea of the extent of the coal-mining industry of Belgium, and of its development during past years. The following data refer to the year 1876.

Statistics: Companies, Laborers, Steam power.

In that year 180 companies were engaged in the exploitation of coal in Belgium, employing in the underground and surface works together, 108,543 laborers with 4,668 horses and 1,645 steam engines, the latter classified as follows:

	Horse-power.
335 engines for extraction, with	39,222
365 engines for ventilation, with	12,312
189 engines for drainage, with	31,828
756 engines for sundry uses, with	8,669
1,645	92,031

Depth of shafts.

With the exception of a small quantity of coal produced in the mines that are situated above the level of the valleys and worked by adits, the coal product of the country is raised from vertical shafts. Many of these do not exceed 300 to 400 feet in depth, while some attain a depth of 2,500 feet. In 1875 there were 322 shafts in operation in Belgium, having an average depth of 1,150 feet.

Coal raised in cars on cages.

The greater part of these shafts are furnished with guides, and the method of extraction is by cages, on which cars are raised from the levels below to the surface. Most of the hoisting engines are non-condensing, some of them having

Style of engines.

500 horse-power and upwards. For pumping, condensing engines are generally, but not always, used. Some of these have from 800 to 1,000 horse-power. In some cases the

Coal.

pumps are operated by means of a balance-bob acting upon the pump-rod, but in more instances the power is direct, the piston-rod of the engine being in line with the pump-rod and connected with it.

Compressed-air engines.

Compressed air as a motive power for machinery employed in mines has been in use in Belgium since 1845, and its application is steadily increasing in extent and in variety of uses.

Iron.

Iron.—The ores of iron worked in Belgium are hematite, limonite, and argillaceous carbonate. The latter occurs sometimes in small quantities with the limonite, and it also occurs independently in deposits, but which are too small to permit profitable exploitation.

Character of ores.

Hematite.

Hematite is found in various forms and in very different geological positions, but it is almost altogether, if not only, in the oolitic form of deposit that it is worked in Belgium. In this condition it forms important deposits in the quartzose schists that underlie the coal measures and crop out on both sides of the valley containing the coal basin. The principal mining operations are on the north side of the valley, where, in the neighborhood of Vedrin, there are four separate strata, having the dimensions of $2\frac{3}{4}$ inches, 4 inches, 8 inches, and $11\frac{1}{2}$ inches, forming with the intercalated schists a bed of nearly 4 feet in thickness.

The ore bed of Vedrin.

Ore beds of Marchovelette, Ville-en-Waret.

At Marchovelette there are five strata, varying in width from 4 to 8 inches. At Ville-en-Waret the developments have shown four strata, of which two are from 8 to 20 inches thick, forming with the interstratified schists a group of 23 to 24 feet. At Houssois, near Vezin, at a point where the outcrop turns abruptly to the southwest, the beds of hematite attain a thickness of about 7 feet. The bed of hematite is traversed at several points by veins and faults, at the contact of which the ore and the inclosing schists are often impregnated by pyrites, galena, and other substances which impair the quality of the iron ore. Along the outcrop on the south side of the valley the developments are much less important than on the north. The principal workings on the south are near Huy, where the formation comprises two layers of hematite having a thickness of little less than four feet, separated by a bed of schist of about one foot.

Houssois, and Huy.

Percentage of metal in the hematite.

The average yield of the hematite ores is from 35 to 40 per cent of metal.

Limonite ore.

The limonite ore also occurs in varied forms and in deposits of very different geological position. In recent form-

BELGIUM.

Iron.

Limonite ore.

ations it forms beds 6 inches to 3 feet or more in thickness, reposing upon argillaceous sands in the depressions of the surface, and mainly along the borders of the rivers Demer, the two Nethes, and their affluents. The ore from these deposits is concretionary and porous, containing about 40 per cent. of iron. It has much phosphorus, but is easily reduced.

Quaternary limonite of Hainaut.

In the Quaternary formation a silicious limonite is worked near Quévy, in the district of Hainaut, which, mixed with argillaceous sand, forms a bed varying in thickness from 3 to 5 feet, resting in a depression of the Tertiary sandstone. The ore contains phosphorus.

Superficial deposits of Luxembourg.

The isolated and superficial deposits of iron ore occurring in the province of Luxembourg, and notably at Ruette, Athus, Toenich, etc., also belong to the Quaternary formation, resting upon the Jurassic, the ore deposits having apparently resulted from the disintegration of Jurassic rocks in the Quaternary age. It contains about 30 to 45 per cent. of metal.

The iron ores of the Jurassic formation.

The Jurassic formation which forms the surface of the southern part of the Belgian province of Luxembourg and of the grand duchy of the same name, and of the northern portion of Lorraine, is also exceedingly rich in iron ore, and furnishes a large quantity to the Belgian iron industry. The ore from this source is known by the name of *minette*, and is an oolitic limonite consisting of fine grains (from one-third to one-sixth of a millimeter in diameter). The ore occurs in deposits, which are very extensive in the localities just named, but of limited extent in Belgium, forming beds near the French frontier about 5 to 6 feet thick. The ore contains 30 to 45 per cent. of iron. The gangue consists chiefly of carbonate of lime, silica, and a little gypsum, and is very fusible.

The limonite deposits inclosed in the primary rocks.

The primary rocks of Belgium, comprised between the lower quartzose schists and the coal formation, inclose many important deposits of limonite, which, up to the present time, furnish the greater portion of the ore consumed in the Belgian iron industry. These ores always occur in masses or veins—never in stratified form. The deposits are often of large dimensions.

Table of production, etc.

The following table shows the production, importation, and exportation of iron ores in Belgium during a series of years. The notable decline in the production in late years finds its explanation in the fact that the Belgian furnaces are con-

Iron.

stantly drawing their supplies of ore (minette) more and more from the Grand Duchy of Luxembourg:

Table of production, importation, and exportation of iron ores: 1850–1876.

Years.	Iron ores.		
	Produced.	Imported.	Exported.
	Tonnes.	*Tonnes.*	*Tonnes.*
1850	367, 360	.....	.....
1860	809, 176	1, 486	152, 114
1865	1, 018, 231	301, 846	230, 539
1867	603, 829	322, 891	152, 227
1868	519, 740	396, 283	136, 067
1869	628, 046	551, 900	164, 576
1870	654, 332	568, 571	179, 867
1871	697, 272	594, 406	162, 566
1872	749, 781	790, 503	178, 997
1873	503, 565	739, 541	215, 042
1874	527, 050	738, 835	109, 144
1875	365, 044	804, 370	141, 767
1876	269, 206	671, 134	166, 418

Source of imports.

Of the entire quantity of iron ores imported in 1875, 1876, and 1877 about three-fourths were brought from the Grand Duchy of Luxembourg; the remainder mainly from Prussia, France, Netherlands, Spain, and Algeria. The iron ores exported in same years were sent mainly (over 90 per cent.) to France; nearly all the remainder to Prussia and the Netherlands.

Destination of exports.

Table of production, importation, and exportation of pig-iron: 1840–1876.

The following table shows the amount of pig-iron produced in, imported into, and exported from Belgium during a series of years:

Years.	Pig-iron.			Blast furnaces in operation.
	Produced.	Imported.	Exported.	
1840	.....	.....	10, 438	.....
1850	144, 452	.....	92, 345	41
1860	819, 943	725	22, 086	51
1865	470, 767	24, 864	10, 711	56
1867	423, 069	53, 385	11, 062	.....
1868	435, 754	42, 549	16, 525	.....
1869	534, 319	61, 600	14, 206	.....
1870	565, 234	82, 330	10, 176	48
1871	609, 230	84, 299	48, 526	49
1872	655, 565	137, 008	49, 096	52
1873	607, 873	145, 212	27, 208	54
1874	532, 790	158, 291	16, 188	55
1875	540, 473	146, 886	15, 672	42
1876	490, 508	207, 204	9, 479	31

The iron industry of the Belgæ in the Roman period.

The iron industry of Belgium is very ancient. In the time of the Romans the inhabitants of the Belgian provinces were noted for their skill and industry, and were well acquainted with the arts of the production and manufacture of the metals. The ruins of two furnaces of that period were discovered a few years ago at Lustin, between Namur

BELGIUM.

and Denant, which threw much light upon the methods of producing iron then in use. In the twelfth century the iron industry had already attained a high degree of excellence in the Netherlands; and in 1560 there were in that country not less than 35 melting furnaces and 85 forging establishments. About the year 1800 great improvements were introduced in the form of furnaces, increasing their height from 15 to 25 feet, and greatly enlarging their productive capacity.

Iron.

Iron industry in the 12th century.

In the 16th century.

Improvements about 1800.

The largest iron and steel establishment in Belgium is that of the *Société John Cockerill*, at Seraing, founded in 1817. It employs 8,750 workmen, aided by 259 steam-engines of 6,600 horse-power. Its daily consumption of fuel exceeds 1,000 tonnes, and its annual production has a value of about 32,680,000 fr., or about $6,500,000.

Société John Cockerill.

Statistics.

Lead and Zinc.—The principal ore of lead mined in Belgium is galena. It occurs only in the older formations, where it is found in veins or in masses, and either alone or associated with zinc blende and pyrites. The gangue of the veins is generally a carbonate of lime, barite, and quartz, with clay and with limonite; in the masses the gangue is commonly a dark clay.

Lead.

Galena.

Mode of its occurrence.

In some places the galena is often accompanied with other lead minerals, such as cerusite (the carbonate), which is quite frequent, and pyromorphite (the phosphate), which is comparatively rare.

Associates of the galena.

Galena occurs in numerous veins in a number of places, many of them too unimportant for exploitation. The principal lead-mining operations of Belgium are in progress in the celebrated vein at Bleyberg, near Moresnet—the only vein in the country which, after having traversed the Carboniferous limestone, penetrates the coal formation. At the line of contact it forms very considerable masses, which, however, are worked with great difficulty, on account of the enormous quantity of water there, involving the necessity of very expensive machinery for its removal.

Mine at Bleyberg.

The zinc ore most important in the production of that metal in Belgium is commonly known as calamine. It is a combination of different oxides of zinc, in which the carbonate, smithsonite, predominates. Calamine, properly so called, that is, the hydrous silicate, is comparatively rare, as also is the anhydrous silicate, willemite. Zinc blende forms also a considerable item in the production of the mines, but its treatment being comparatively difficult it is less sought for than the other ores of zinc. In Belgium the ores of zinc, like those of lead, are found only in the older forma-

Zinc.

Calamine.

Blende.

Zinc.

Mode and place of occurrence of zinc ores.

tions, chiefly the Devonian and the Carboniferous limestone, occurring in veins and masses, associated with galena and pyrites. The localities are numerous, but the most important are in the eastern portion of the province of Liège. The ore there is calamine, generally associated with blende and galena. The ore bodies occur as masses of very considerable dimensions and in various geological positions, but generally at the contact of the Carboniferous limestone and the coal formations. The ores of these masses, which are sometimes hundreds of meters in length and breadth, have a gangue of clay and sometimes limonite, which is worked for iron ore.

Product of lead and zinc.

In 1876, in Belgium, the lead product was 6,963 tonnes, and the zinc product (crude metal) was 49,960 tonnes.

Bleyberg mines.

BLEYBERG-ES-MONTZEN.

Character and strike of the vein.

The Bleyberg vein is situated in the Carboniferous lime stone and in the Coal Measures, the latter of which overlie the former. The fissure penetrates both and has a general strike northwest and southeast, forming an angle of 57° with the meridian and 115° with the lines of stratification. It has been recognized for a distance of five kilometers in the Coal Measures and of above two kilometers in the limestone. It either stands vertically or dips at an angle of 75° or 80°, sometimes to the east and sometimes to the west. No fault or cross-course has been met with, but it is believed that a change of direction toward the north may be the result of such a phenomenon.

Contents of the fissure.

The fissure is partly filled with fragments of the country rock. In some places these fragments are entirely surrounded with ore. In others, where the adjacent rock is of a readily decomposable character, the débris has been so closely packed as nearly or quite to exclude the deposition of ore.

Galena and blende. Order of deposition.

The ores are essentially galena and zinc blende, and of these the zinc blende appears to have been deposited before the galena; for while masses and layers of zinc blende are found free from galena, the masses of galena are invariably mixed with zinc blende. Small quantities of copper, antimony, and silver minerals are also met with. Wherever the interstices between the fragments of wall rock were of any size, the ore exhibits the ordinary banded structure.

Occurrence of other metals.

Theory as to the associated crystals in the vein.

Subsequently to the deposition of the ore, calcite quartz and iron pyrites have crystallized out from solution, and now form a portion of the vein matter.

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Bleyberg mines.

Many phenomena make it evident that subsequently to the filling of the veins the fissure has reopened and closed again. This action has resulted in slickensides, the disturbance of the original deposits of ore, and the fracture of the mineral crystals.

Width of metalliferous portion of the vein.

The metalliferous portion of the vein has a total width of 90 centimeters; in those portions of the vein which are densely filled with débris, and in which the walls have given way extensively, the width is much greater.

Vein traverses the limestone and the coal measures.

No difference is perceptible in the mineral filling of the vein between those portions which traverse the limestone and those in which the walls belong to the Coal Measures. At one point in the limestone a cave 500 meters long and 70 meters wide and about the same depth adjoins the vein on the hanging wall. Large quantities of ore of banded structure have been deposited upon the sides of this cave, but the greater portion has been dislodged by violent earthquake shocks, and has rolled down in fragments into the fissure. Enough is left in place, however, to show the origin of what has been dislodged.

Banded ore cave deposits.

Remarkable bedded mass of galena.

At the contact between the limestone and the Coal Measures, and adjoining the vein, a remarkable bedded mass exists. It is supposed that at this point there was a valley, where a sort of lake was formed, which was fed for a long time from springs highly charged with plumbiferous matter.

Theory as to the mode of its deposit.

The result was the formation of a large mass of galena without partings and reposing solidly upon the underlying rocks, and was not broken up by the force which reopened the fissure. This deposit is only some 40 meters from the present surface; it is covered with materials originating in the Coal Measures, with various clays, and with Tertiary strata, which are horizontal and lie unconformingly on the limestones and coal measures.

The overlying strata.

Immense flow of water into the Bleyberg mine.

There is said to be no mine where the flow of water is so great as at Bleyberg. The average quantity is 33 cubic meters per minute, but the amount occasionally rises to the enormous figure of 45 cubic meters (nearly 1,600 cubic feet, or 12,000 gallons) after heavy rains or when the snow is melting. The quantity pumped from a depth of 182 meters has been for some years past 18,000,000 cubic meters. This tremendous flow of water is due to the geological conformation of the surrounding country. The mine lies between two ridges in a synclinal, in such a way as to receive the drainage of a large area. The basin is, indeed, in part drained by the river Gueule and its tributary brooks, but wherever these streams pass over porous or broken ground,

Quantity pumped.

Cause of the great inflow of water.

BELGIUM.

water from them, too, percolates into the mine, and in such quantities that it has been necessary to convert the beds of the streams into canals by covering them with clay held in place by stone flags. Four thousand meters of the river Gueule and 12,000 meters of its tributaries have been thus treated, together 16 kilometers, or about 10 miles.

Bleyberg mine.

Canalization of the Gueule.

The force employed in pumping amounts to 3,300 horse-power, and the annual cost is 500,000 fr. A water-wheel of 12 meters in diameter and 2.68 meters in width, which drives pumps of 60 centimeters in diameter and 1.50 meters stroke, was, up to 1847, the principal engine used in pumping, and still develops a force equal to 90 horse-power. Cornish steam-pumping engines were introduced in 1847, and in 1867 the company had the credit of ordering, and the John Cockerill Company of building, the first powerful rotary engine employed in pumping. This machine is a direct-acting compound condensing engine of 640 horse-power; the fly-wheel with its shaft weighs 52 tons, and the pistons have, respectively, diameters of 1.63 meters with a stroke of 1.25 meters, and of 2 meters with a stroke of 2.50 meters. The pumps of this engine are force-pumps of 65 centimeters in diameter and 2.50 meters stroke. Their capacity is 840 liters per stroke. The engine makes 10 revolutions per minute, and is supplied with steam from 8 Cornish boilers, with two fires each. This first application on a large scale of rotary pumping-engines has been widely imitated. During six years of constant use no accident has happened to the machine, and it has consumed an exceptionally small amount of fuel. The coal, by actual experiment, is only 1.25 kilos per horse-power. Thanks to the good machinery, the mine has not been shut down for an instant for more than 20 years.

Pumping engines.

Annual cost.

Water-wheel superseded by Cornish engine and that by rotary compound condensing engine.

Capacity.

Duty.

The main difficulty in mining, beyond that caused by water, arises from the want of cohesion of the ore in the large ore bodies. These are extracted by cross-cuttings, while in the veins the method is by overhand stoping. There are numerous shafts for hoisting and ventilation, furnished with engines of from 8 to 12 horse-power. In spite of the great danger caused by the enormous quantity of water and the loose character of the ground, accidents are of very rare occurrence, and the number of miners killed amounts to one in 700 each year.

Difficult character of the mining.

Rarity of accidents.

There is a large ore-dressing establishment attached to the mines, employing a force amounting to 45 horse-power and using 800 cubic meters of water per hour. The machinery consists of jigs, percussion tables, etc., as is usual in works of this class, and the capacity is 180 tons of un-

Ore dressing.

Capacity.

BELGIUM.

dressed ore in ten hours. The ore as it comes from the mines contains 18 per cent. of valuable matter. The zinc ore is brought up to a tenor of 45 per cent., the galena to 80 per cent., and the cerusite and the pyromorphite to 65 per cent.

Percentage of value in the ore.

Furnaces.

The Bleyberg Company treats most of its own ores. The zinc furnaces are of the Belgian type, and the lead furnaces those known in mining literature as "Bleyberg furnaces."

Desilverization.

The loss of fume amounts to almost nothing, and there is no lead colic among the men. The lead is desilverized in the works (process not stated), and the market lead produced is of great purity. The Bleyberg Company is said to have been the first to guarantee the almost chemical purity of its leads, and to sell on the basis of analysis made by both seller and buyer. Hundreds of these analyses might be shown in proof of the excellence of the products. The furnace lead carries only some eight dollars per ton in silver.

Chemically pure lead.

Production 1853–1878.

Since the organization of the company in 1853 up to the year 1878 the works have produced 59,940 tonnes of lead and 29,934 tonnes of zinc. Over $4,000,000 have been distributed in dividends—about four times the original capital.

Dividends.

Workmens' benefits.

The advantages and inducements to workmen to remain in the employment of the company usual in Europe are given at Bleyberg, and in 1867 the company received honorable mention at the Paris Exposition for their care of the welfare of the miners.

Vielle-Montagne Mining Co.

THE VIELLE-MONTAGNE.

The Vielle-Montagne Mining Company is probably the most famous association of the kind in Europe. It derives its importance not only from the extent of its operations, but from the number of establishments counted among its property, and their wide geographical distribution. The following is a list of the works of the company:

Immense extent and wide distribution of its properties.

In Belgium.

BELGIUM.

Welkenraedt.—Mine of calamine, zinc blende, and lead; ore-dressing works; calcining furnaces.

Angleur.—Zinc foundry and rolling mill.

Tilff (near Liège).—Rolling mills.

St. Leonard (at Liège).—Zinc furnaces.

Valentin-Cocq (station, Jemappe).—Zinc furnaces, zinc-white works, and colliery.

Flône (station, Hermalle).—Zinc and lead mines, blende-roasting furnaces, and zinc furnaces.

Baldaz-Lalore (station, Flémalle).—Collieries and coking furnaces.

Moresnet.—Mines of calamine, ore-dressing works, calcining furnaces, and zinc furnaces.

GERMANY.

BELGIUM.

Distribution of properties of Vielle-Montagne Co.

Borbeck (near Essen).—Zinc foundry.
Oberhausen.—Rolling mill; blende-roasting furnaces.
Bensberg.—Lead and zinc-blende mines and ore-dressing works.

In Germany

Ucherath (Siegen district).—Mine of zinc blende, lead, and copper, and ore-dressing works.
Mayen (near Coblenz).—Mines of zinc blende, lead and copper, and ore-dressing works.
Wiesloch (near Manheim).—Mine of calamine; ore-dressing works

FRANCE.

In France.

Asnières (near Paris).—Zinc-white works.
Bray (Euse).—Rolling mills.
Sainte Marie (Oise).—Rolling mills.
Droittecourt (Oise).—Rolling mills.
Vivies (Aveyron).—Furnace.
Penchot (Aveyron).—Rolling mills.

SWEDEN.

In Sweden.

Ammeberg (near Askersund).—Mines of zinc, copper, and cobalt, ore-dressing works, and blende-roasting furnaces.

ALGERIA.

In Algeria.

Hammam and *Aïn-Safra* (province of Constantine).—Calamine mines.

SARDINIA.

In Sardinia.

Various calamine mines, owned wholly or in part by the company, in the district of Iglésias.

The company has, besides, numerous agencies in various countries for the purchase of ores and for the sale of products.

Collective horse-power of engines.

The establishments above enumerated contain 179 engines, representing a collective power equal to about 4,450 horse-power—English.

BELGIUM.

Vielle-Montagne Mining Co.

Table of products, purchases, and sales: 1860–1877.

Table of the products, purchases, and sales of the Vielle-Montagne Mining Company from 1860 to 1877.

[In tonnes of 1,000 kilos (2,205 lbs.).]

Years.	Mines of the Vielle-Montagne.			Purchases of zinc ores, calamine and blende.	Roasting, quantities of ore roasted.	Calcination of calamine, quantities of ore calcined.	Product, crude zinc.	Sheet-zinc rolled.	Zinc-white manufactured.	Sales of zinc and zinc-white.
	Zinc ores, calamine and blende.	Lead ores.	Collortes.							
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
1860	47, 065	1, 208	98, 687	21, 024	11, 670	30, 196	28, 925	20, 647	5, 653	26, 169
1861	52, 009	1, 808	97, 873	12, 243	11, 741	33, 006	25, 601	22, 074	5, 317	30, 849
1862	54, 061	1, 755	92, 959	27, 867	18, 819	31, 841	23, 676	21, 795	5, 885	26, 885
1863	51, 202	2, 010	97, 824	29, 875	20, 863	26, 489	27, 553	23, 303	4, 362	33, 888
1864	54, 640	2, 230	89, 811	41, 004	20, 312	26, 211	28, 115	20, 795	4, 954	30, 582
1865	54, 876	2, 275	97, 912	50, 015	30, 259	24, 127	30, 502	21, 857	4, 860	27, 217
1866	53, 113	2, 201	106, 280	57, 567	33, 528	21, 249	31, 722	22, 054	5, 523	27, 462
1867	53, 302	2, 721	97, 800	50, 175	32, 470	22, 272	36, 200	23, 408	5, 342	36, 083
1868	64, 402	2, 736	89, 816	61, 026	23, 898	30, 609	40, 219	24, 976	5, 419	39, 367
1869	67, 314	2, 490	89, 452	57, 901	23, 603	27, 472	42, 037	28, 216	5, 905	44, 441
1870	66, 426	2, 581	96, 987	94, 494	27, 048	35, 522	42, 112	25, 302	5, 792	47, 106
1871	63, 197	3, 498	93, 913	46, 212	26, 007	33, 025	41, 129	30, 228	5, 949	42, 564
1872	63, 551	4, 165	94, 626	78, 968	22, 270	38, 912	39, 663	31, 102	6, 551	43, 458
1873	51, 824	4, 388	87, 135	66, 026	15, 963	30, 311	40, 295	32, 204	5, 666	39, 539
1874	54, 298	4, 746	77, 338	67, 184	20, 251	35, 414	40, 399	31, 661	6, 041	42, 845
1875	53, 921	5, 329	51, 690	69, 794	22, 066	26, 180	41, 658	34, 990	6, 501	43, 385
1876	54, 569	5, 914	78, 110	65, 161	20, 388	16, 604	38, 518	35, 416	4, 984	40, 194
1877	68, 095	6, 833	58, 499	85, 187	32, 600	28, 440	43, 288	34, 967	5, 689	42, 906

The following data as to the employés of the company for the year 1877 may be of interest:

Vielle-Montagne Mining Co.

Statistics of workmen, wages, etc.

Average number of workmen employed	7,121
Number of persons dependent on their wages	14,481
Total number of persons supported by wages paid by the company	21,602
Regular wages paid for the year	$1,318,830
Premiums paid for extra good work	$118,877
Total amount paid to hands	$1,437,707
Number of days' work done	2,290,699
Mean salary per head per day	$0.63

Workmens' benefits.

As will be seen from the foregoing table, a considerable sum is yearly expended in the encouragement of excellence in workmanship and of faithfulness in discharge of duty on the part of the men.

Provisions for workmens' residences, sick funds, recreations, etc.

The wages paid are low, but the men enjoy a number of facilities not offered by American mining companies. The company provides quarters, commonly cottages with gardens attached, at very low rates, and encourages the purchase of these houses on a very favorable installment plan. It also contributes largely to hospital insurance funds, to the support of schools and of churches, and even aids in the support of various clubs, musical societies, etc. In short, a systematic effort is made to attach men permanently to the service of the company.

Moresnet.

Note on the deposit of zinc ore and the smelting works at Moresnet.

Deposits of calamine. Kelmisberg.

The deposit of calamine of Altenberg or Kelmisberg belonging to the Vielle-Montagne lies in the lower part of the limestone strata of the Carboniferous formation. This limestone is for the most part converted into dolomite. It occupies the extremity of a zone which simulates a basin raised toward the surface on one side and buried on the other. At the place where the metalliferous deposit occurs it reaches a width of 600 meters. This basin of dolomite and ore is in its turn inclosed in soft dry Devonian schist, which rises on both sides of the basin. A bed of quartzose dolomite, carrying large quantities of water, separates the two rocks. This bounds the dolomite formation and the whole deposit with remarkable regularity.

Geological occurrence.

Deposit of rich and pure carbonate.

This ore, which is composed, toward the surface, principally of carbonate of zinc of great purity and richness, and without a trace of lead or zinc blende, has filled the basin thus raised on one side nearly full, and crops out on the surface to a very considerable extent.

BELGIUM.

Vielle-Montagne Mining Co.

The formation of Kelmisberg, which is entirely surrounded by dolomite, does not anywhere come in contact with other rocks, and must be considered as resulting from *the slow and gradual change of the inclosing rock into ore by an exchange of bases.* It cannot possibly be considered as a deposit of secondary origin, such as many of the contact deposits of the country unquestionably are.

Formation of Kelmisberg.

This remarkable deposit was most largely developed towards the surface; its length may have reached 450 meters, and its breadth from 100 to 150 meters.

Theory of the mode of deposit.

The whole of the hollow formed by the basin at the surface appears to have been filled with ore, or with rock impregnated with metalliferous salts. The most highly concentrated and most remarkable portion of this ground is situated at the northern extremity of the basin, and is almost entirely separated by a projecting point of dolomite from what is known as the southern body. Toward the southwest the deposit is continuous, but is hidden under the dolomitic rocks. It has been followed to the considerable depth of 110 meters, and it is between this level and a depth of 75 meters that the actual workings are being carried on. The filling, that is to say, the metalliferous substance, appears to have been very different at the surface from what it is in depth. While at the surface the ore was nearly pure carbonate, lower down it was mixed with hydrated silicate, which gradually increased until at a certain depth it came to form the larger portion of the ore. Anhydrous silicate, willemite, so characteristic of the Kelmisberg deposit, has always been found in large masses, of a hundred cubic meters or more, scattered without any rule in the mass of the other ores, and completely surrounded by them.

Change in the character of the ore at lower depths.

First workings in the 15th century.

The first shafts are said to have been sunk in the northern deposit, in the fifteenth or sixteenth century. Without any knowledge of the metal which the ore contained, the brass-founders at Aix-la-Chapelle and its neighborhood used the mineral in its crude state. From ancient times and up to the beginning of the nineteenth century, when the Abbé Dony constructed the first furnace for the reduction of zinc (1806), the amount of ore taken from the deposit at its croppings was inconsiderable. The work done after the beginning of this century was no doubt more thorough, but it was not until 1846 that regular or serious operations were begun.

Use by brass-founders of the crude ore.

Abbé Dony's furnace of 1806.

Regular proceedings in 1846.

Yield of 1855.

In the year 1855 the yield was probably the greatest which had ever been taken from a metalliferous mine of this

description. It reaches the figure of 137,000 tons of ore as it came from the mine, or 50,900 tons of concentrated ore; the northern deposit was the ore principally worked by former generations, but it yielded a large amount of ore as an open cast between 1846 and 1856, when the bottom of the basin was struck at from twenty-five to thirty meters below the surface. It is estimated that in all no less than 1,500,000 tons were thus removed up to 1856.

Vielle-Montagne Mining Co.

Yield of mines of Kelmisberg up to 1856.

From the year 1856 on, the workings have been entirely underground, and have embraced both the north and south ore bodies. The whole quantity of ore extracted from these deposits is known to amount to at least 200,000,000 tons, representing about a million and a half tons of first-class tenor and quality. The ore-dressing works were built in 1850, and since that time have been brought to the highest state of perfection, and are almost altogether automatic; 200 tons of material can here be treated in ten hours, and yield above 80 tons of concentrations. For some years past the ores from the ancient waste-dumps and those from the newer workings have been separately treated.

Subsequent yield of the workings.

Ore dressers.

Capacity.

The smelting works handle only the ores from this locality. These are for the most part very refractory, being mixtures of silicate and carbonate, and are often at the same time very fusible, from the presence of double silicates of lime and alumina. These two circumstances make reduction very difficult, for it can only take place at very high temperatures, which are accompanied by the formation of slag and consequent losses.

Smelting works.

The furnaces employed are on the Belgian system, and contain 130 tubular retorts each.

Furnaces.

The works possess four blocks of furnaces charging 2,400 kilos of ore, reaching an average production of 850 kilos of metal, with a consumption of 3,300 kilos of coal per 24 hours, of which 20 per cent. is lean coal and the rest bituminous.

Capacity.

It is at the works of Moresnet exclusively that the almost chemically pure zinc is produced which is employed in making *blanc de neige* and for art-castings.

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IX.

AUSTRIA-HUNGARY.

THE AUSTRO-HUNGARIAN EXHIBIT.

Source of the information: Dr. H. F. Brachelli.

The following outline of the present condition of the mining industry of the empire is made up of material presented in the official catalogue of the Austrian exhibit and gathered by Dr. H. F. Brachelli.

Great variety of ores in the Empire.

The Austro-Hungarian Empire is exceedingly rich in ores and technically valuable minerals, and is not surpassed by any other state in Europe in respect to their variety. A greater development of the mining industry of the country is, however, most desirable.

The number of persons employed in this branch of industry and the results for 1875 were as follows:

Table of workmen and product; 1875.

	Austria.	Hungary.	The empire.
WORKMEN.			
At the mines ..... number..	83,561	42,391	136,410
At smelting works ..... do...	10,438		
At the salt works ..... do...	8,805	1,192	10,797
Total	102,824	44,383	147,207
VALUE OF PRODUCT.			
Mines ..... florins..	42,800,000	19,700,000	87,700,000
Smelting works ..... do...	25,200,000		
Salt works ..... do...	20,600,000	10,200,000	30,800,000
Total	88,600,000	29,900,000	118,500,000

Assumed value of the florin.

These values appear to be given in paper florins, which fluctuate slightly in value. From the value of the silver product mentioned in Dr. Brachelli's essay I have calculated that the florin, as used by him, is equivalent to $0.4435, while the value of the silver florin is $0.4878.

The eminent domain of the crown.

All mineral deposits of technical value are property of the crown, and prospecting and exploitation can only be undertaken with the permission of the mining authorities, whose duty it is to see that all mining operations are carried out according to law. A large proportion of the most valuable mines in the empire are owned and worked by the state.

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The principal results of the mineral industry in 1876 were as follows:

Mineral produce of Austria-Hungary in 1876.

Mineral products of the Empire in 1876.

	Austria.	Hungary.	The empire.
Gold.....kilos..	14	1,890	1,904
Silver.....do...	25,166	22,784	47,950
Quicksilver.....do ..	375,400	23,100	398,500
Iron .....tons*..	273,046	127,379	400,425
True coal.....do...	4,934,335	636,991	5,571,326
Brown coal.....do ..	6,933,382	884,139	7,817,521
Salt.....do ..	249,465	120,115	369,580
Copper.....do...	442	1,025	1,467
Lead and litharge.....do...	7,529	2,419	9,948
Zinc .....do...	3,979	567	4,546
Tin.....do...	207	.....	207
Graphite.....do...	12,717	.....	12,717
Petroleum .....do...	1,064	1,967	3,031

*Of 1,000 kilos or 2,205 lbs.

Besides these a number of others might be enumerated, such as ores of cobalt, nickel, manganese, arsenic, bismuth, antimony, and uranium, and some others.

A few words on the distribution of the valuable minerals may be a not unwelcome addition to the table.

Occurrence of minerals and metals:

Gold is found in notable quantities only in Hungary and Transylvania, *Silver* in the same countries and in Bohemia; *Quicksilver* almost exclusively at Idria in Carniola, but deposits occur in Carinthia, and a small quantity is obtained in Hungary from tetrahedrite. *Iron* is found and smelted in almost every province of the empire, but Styria leads in this branch, and produces over a quarter of the whole. *Coal*, both true and brown or (in part) lignite, is found in large quantities in the northern portion of the empire, in Bohemia, Moravia, Austrian Silesia, and Galicia. Hungary also produces some coal, but the southern provinces are badly off for fossil fuel. *Salt* is found in enormous and uncontaminated deposits in the Carpathian Mountains and is also won by solution in great quantities in Salzburg. *Copper* is found chiefly in Salzburg; *Lead* in Bohemia, at Pribram, while in Carinthia, Villach is a famous lead-producing locality. *Zinc:* Western Galicia, Carinthia, and Carniola produce zinc, and the Tyrol must now be added, as will appear in this report. *Tin* is obtained only at one or two spots in Bohemia (Zinnwald, etc.). *Graphite* comes mostly from Bohemia, but is likewise obtained in Moravia and Southern Austria. *Petroleum* is found in Galicia, as are also the paraffin minerals, but not nearly in sufficient quantities to supply native consumers.

Gold.

Silver.

Quicksilver.

Iron.

Coal and lignite.

Salt.

Copper: lead.

Zinc.

Tin.

Graphite.

Petroleum.

Mining has been dull of late years in the empire, except in the collieries, which have increased their output largely,

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owing chiefly to the large exportation of brown coal, which is however partially balanced by a large importation, mostly of Prussian coal.

Coal.

Coal.—The development and extent of the coal production of Austria-Hungary may be seen from the following table, in tonnes:*

Output of coal: 1860–1876.

Years.	True coal.	Brown coal.	Total.
1860	1, 948, 189	1, 548, 306	3, 496, 495
1865	2, 836, 884	2, 232, 419	5, 069, 303
1870	4, 295, 775	4, 060, 169	8, 355, 944
1871	4, 969, 980	5, 078, 058	10, 048, 038
1872	4, 788, 455	5, 767, 612	10, 556, 067
1873	5, 171, 189	6, 732, 884	11, 904, 073
1874	5, 096, 659	7, 183, 098	12, 279, 757
1875	5, 185, 234	7, 666, 812	12, 852, 046
1876	5, 564, 331	7, 798, 255	13, 362, 586

* *Kohle und Eisen*, by J. Pechar.

Relative greater increase of lignite production.

It is a remarkable fact, and one of great importance to Austria, that, as may be seen from the figures, the increase in the product of lignite is much more rapid than that of true coal. This is a consequence of the rapid increase in the production of the lignite fields of the Erzgebirge, which yield brown coal of a peculiarly good quality. Austria, to

Coal fields limited,

be sure, has no true-coal fields to be compared with those of England or Westphalia. On the contrary, the coal fields are of small extent, with the exception of that of Kladno-Schlan-Rakonitz, and are, moreover, frequently of such a

but of good quality.

character as to be worked only with difficulty; the quality of the coal, however, is for the most part excellent, especially for coking.

Localities of the coal.

The Austrian true-coal fields lie for the most part on an east and west line, beginning at Pilzen, on the Bavarian frontier, and reaching to Galicia, on the Russian frontier; there is, however, also coal in the east and southeast of Hungary, in the Fuenfkirchen and Styerdorf basins.

The lignite deposits.

The lignite deposits of Austria are inexhaustible and easily worked. This fuel is not alone excellent for household use, but answers the purpose of many branches of industry, for raising steam, etc. It has even been used in iron blast furnaces.

The lignite fields of the Erzgebirge;

The most important lignite or brown-coal fields extend along the southern slope of the Erzgebirge. The output from this district is greater than that from any other in Austria, and was 4,800,000 tonnes in 1876. Other less extensive brown coal districts lie between the spurs of the

and elsewhere.

Alps, especially upon their eastern slope in Steyermark and Carniola; finally, there are deposits of brown coal in Hun-

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gary and Transylvania. That of the Zillthal is said to be particularly promising. The following shows the relations of the Austro-Hungarian coal trade:

Table of importation, exportation, and consumption of coal.

Years.	Importation.	Exportation.	Consumption.
	Tonnes.	*Tonnes.*	*Tonnes.*
1860	240,128	279,675	3,456,948
1865	366,488	385,662	5,050,129
1870	927,119	925,198	8,357,865
1871	1,368,974	1,046,501	10,365,511
1872	1,587,800	1,167,401	10,876,466
1873	1,785,266	1,681,029	12,008,310
1874	1,627,355	2,160,812	11,746,300
1875	1,627,942	2,708,237	11,776,751
1876	1,574,575	2,734,862	12,202,299

Explanation of the terms "importation" and "exportation":

This table requires some comment. While in the tables representing the coal trade of most European states "importation" means importation from England, this is not the case with Austria. The political boundaries between Germany and Austria pass through the coal region of Central Europe. Silesia, in Prussia, and Galicia and Moravia, in Austria, form, properly speaking, one true-coal field, and the brown-coal regions of Bohemia are more or less continuous with those of Saxony. Accordingly, there has been a lively trade in both species of mineral fuel across the German line ever since the railroad communication between the countries was established. The importation of coal in the table represents almost exclusively Silesian coals, and the exportation Bohemian brown coal carried to Germany.

The mutual traffic between Silesia and Bohemia.

Purposes for which coal was consumed in 1875.

The following table shows the purposes for which coal was consumed in 1875, so far as it has been possible to ascertain them:

	Per cent.
Railways	15.5
River boats	2.0
Manufacturing	55.0
Household and trade consumption	27.5

Workmen employed in Austrian coal mines in 1876.

The number of persons employed in the coal mines of Austria (excluding Hungary) in the year 1876 was as follows:

	Men.	Women.	Children.	Total.
True coal	32,968	2,680	735	36,383
Brown coal	24,238	1,780	252	26,270
Total	57,206	4,460	987	62,653

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The number of steam-engines in use in the coal mines of Austria, again excluding Hungary, in 1876 was as follows:

Steam-engines in use in Austrian coal mines in 1876.

	Hoisting.	Pumping.	Hoisting and pumping.	Total.
True-coal mines	187	175	37	399
Brown-coal mines	229	198	48	475
Total	416	373	85	874

Austrian ore-mining exhibits.

Several of the Austrian mines made instructive exhibits illustrating the geological occurrence of deposits and the methods of mining and smelting the ores.

In addition, an excellent account of the exhibiting mines was prepared for the occasion, and sold at a merely nominal price. This pamphlet is entitled *Notice sur quelque-unes des principales mines de l'état Autrichien*, and it is believed that the purposes of this report will best be served by translating literally the greater portion of this authorative and well-digested description, with occasional omissions or abbreviations.

Report on Austrian mines exhibiting in Paris.

Pribram.

Pribram.

Its position.

The town and mines of Pribram are 51 kilometers south-east of Prague, upon a table-land some 500 to 600 meters above sea-level, which is crossed by low ranges of hills.

History.

It is not known when mining began at Pribram. Concessions to reopen the mines were granted in 1527, since which time they have been worked more or less actively. But it was not until the greater part of the mines became state property, at the end of the eighteenth century, that the era of their real prosperity began.

Geological occurrence of the metalliferous deposits.

The metalliferous deposits of Pribram are veins which occur in the lower beds of the Silurian formation of Bohemia, the "*étage A*" of M. de Barrande. The rocks are principally sandstone, quartzites, conglomerates, and schists, bounded to the east and west by granite and a thin stratum of primary slates of M. de Barrande's "*étage B.*" These latter rest conformably upon the older slates. Next come the sandstones of the Grauwacke, which in their turn are covered by Grauwacke slates of a mean thickness of 1,000 meters. Above the Grauwacke lie the sandstone and quartzite forming the extreme limit of the metalliferous deposits. All these beds have a strike of from 60° to 75°. Between the sandstone and the higher Silurian strata to the west of Pribram and of the Birkenberg occurs a fault of great length

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and of some centimeters in thickness, which is filled with dark gray clay. The strike of this fault is very constant—N. 56° E. Its dip is 75° N.

Pribram.

Numerous metalliferous veins and dikes of diorite cross the lower Silurian strata. Most of the veins show gossans at the croppings, and are filled with argentiferous galena only at the depth of 100 meters and more. The thickness of the veins now being worked varies from a few centimeters to six meters and over. Besides galena, the veins contain black-jack or zinc-blende—poor in silver—iron spar, and often calcite, ruby silver, and tetrahedrite, while argentite and native silver are rarely found. The galena occurs in stringers, or in veins, or in lenticular masses, or disseminated in the compact and quartzose gangue. Many veins have been explored for a long distance, both in the strike and dip, without showing any decrease in richness or sensible variation in the gangue; on the contrary, it may be affirmed that the thickness and the contents in silver increase with the depth.

Nature and contents of the veins.

Almost all the veins now being worked appear in the Grauwacke, many of them pinching and growing poorer towards the surface, as they enter the more tenacious strata of this formation, while the contents of other veins are enriched in the upper portions in spots, or in the line where they enter the Grauwacke. Some of the veins cross the fault above mentioned, and have been recognized at a great distance in the schists on the other side of the fault.

Character of the veins.

There are nineteen shafts at Pribram, which are connected at various levels. The deepest is at Adalbert, which has reached the depth of 1,020.1 meters and has thirty levels. It is the deepest perpendicular shaft in the world. At the thousand-meter level a station for magnetic observations is established. The underground workings also communicate with one another through the great drainage-tunnel "Joseph II," which is 21,906 meters long. All the water of the mines is raised to the level of this tunnel, which is 445 meters above sea-level. The total length of thegalleries is 245,089 kilometers.

The workings.

The great drainage-tunnel.

The exploitation is effected through the shafts and galleries, which latter are driven at vertical distances of from 50 to 70 meters, and from a system of levels. The sinking of the shafts goes on constantly, and powder or dynamite are used in the operation in conjunction with machine drills. By this method of exploration thirty-five veins have been discovered, of which the Adalbert is the principal, not only in its regularity and permanence in strike and dip, but in

Exploitation.

The Adalbert vein.

AUSTRIA-HUNGARY.

Pribram.

the grade of its ores. Finally, several isolated aggregations and feeders running into the walls of the veins have been found, and most of them are workable.

Mode of working.

The ore is almost always extracted by overhand stoping, exceptionally by underhand stoping. The country rock being for the most part strong, there is scarcely any timbering in the galleries. When a drift cuts through weak strata, it is temporarily timbered, and subsequently walled.

Mining cars.

The haulage is performed in "Hungarian dogs" (small, three-wheeled buggies) and cars running on rails, of which there are 37,125 meters laid in the mine. For some years past the haulage has been effected at the Adalbert Mine by horses, one animal drawing from 4 to 6 cars, each containing about 900 kilos of ore.

Compressed-air engines.

In the underground workings of a certain depth hoisting engines are employed, which are run by compressed air from a compressor above ground, and at a distance of about 1,000 meters.

Hoisting cages.

In the large shafts the hoisting is effected on cages by cast-steel wire ropes, made on the premises. For the deeper shafts the rope is tapered toward the lower end. The motors are almost altogether steam-engines. The miners go

Man-engines.

down and come up either on cages or man-engines, rarely on ladders.

Annual production.

The annual production is—

	Tons.
Ore requiring sorting	4,000
Ore requiring crushing	60,000
Ore requiring dressing	145,000
Mixed ores	1,000

Sorting.

The first hand-picking is done underground. The high-grade ore is hoisted separately to grass, where it is resorted and passed on to the smelting works; 3,000 tons of smelting ore are thus obtained, with a mean contents of 65 per cent. lead and 0.45 per cent. silver.

Dressing.

The mechanical dressing (stamping, crushing, settling, classification, and separation by water) takes place in four large mills, distributed so as to reduced transportation to a minimum.

Breakers, stamps, settling tanks.

These mills are furnished with rock-breakers, stamps, settling tanks, and a very complete array of ore-dressing machinery. The writer of this report noticed in visiting the

Percussion tables and jigs.

works that lateral and terminal percussion tables and continuous jigs were the machines most employed in the final concentration. The favorite material for the lateral percussion tables (Rittinger's Stossherd) seemed to be cast iron, planed smooth. California stamp-batteries were introduced

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some time since, but were abandoned again for the old style "on account of the rapid wear of the cams." This is an experience not readily accounted for by those who are familiar with these batteries on the Pacific slope.

Pribram.

Concentrating mills.

The water for the concentrating mills is furnished by four large reservoirs, with a total capacity of 2,250,000 cubic meters. The annual product of these mills is—

	Tons.
Smelting ore	5,800
Blende	600
Spathic iron ore	90

Steam-engines.

The fixed steam-engines supplying mines and mills with power number 34, with an aggregate of 1,579 horse-power, besides water-power equivalent to 274 horse-power, and a number of steam pumps, hammers, portable engines, etc.

Smelting works.

The smelting works are provided with all the apparatus necessary to work up the products of the mines, of which the *Notice* gives only a list.

Roasting furnaces.

The method of smelting is what is known as the "Commern process" in Germany; *i. e.*, the galena is roasted in large reverberatory furnaces in which the ore is gradually moved towards the fire. In front of the fire-bridge it is melted down in order to decompose lead sulphate by silicic acid, and get the roasted product as a slagged mass, which is broken into lumps. The ore so prepared is smelted in high furnaces of the Pilz type, only a trace of regulus being found in addition to the lead. The latter is desilverized and the argentiferous lead refined. This process is applicable in Pribram on account of the freedom of the ores from copper.

Smelting furnaces.

Desilverization.

Workmen employed.

The workmen employed in the mine number 3,500, in the ore-dressing works 1,000, and in the smelting works 400.

Workmen's beneficiary institutions.

The Pribram Mine has a mutual insurance fund which provides pensions for workmen no longer able to earn their living and for widows and orphans. Medical treatment and medicine, and in some cases assistance and money, are also furnished out of the fund, which amounts to 370,321 florins, or, say, half as many dollars. It is controlled by a committee elected by the workmen. Its revenue consists in drawbacks from wages and payments made by the works, which amount to one-half those made by the men.

Increasing product.

The *Notice* gives the production of Pribram for 100 years. Less will serve the present purpose. The product is rapidly increasing, and there has been a net profit every year since 1818

Pribram exhibit.

The exhibit made by Pribram included sections of views, samples of ores of different grades, products of ore-dressing

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processes, furnace products, wire ropes, maps and plans, and surveying and magnetic instruments.

Pribram.

Product of the Pribram Smelting Works.

Production: 1860–1877.

Years.	Fine silver.	Litharge.	Lead.	Profit.
	Kilos.	*Kilos.*	*Kilos.*	*Florins.*
1860	12,807	858,256	340,684	119,298
1865	14,286	1,384,004	369,650	227,720
1870	15,390	797,410	1,065,978	757,204
1871	16,274	1,627,956	500,990	634,429
1872	16,824	1,605,263	641,194	495,527
1873	18,053	1,904,302	939,464	693,415
1874	20,351	2,333,926	1,054,330	683,761
1875	22,857	2,846,116	967,670	774,728
1876	23,750	2,868,638	962,119	981,002
1877	27,015	3,466,306	1,292,125	1,288,722

Joachimsthal.

Joachimsthal.

Position.

The little town of Joachimsthal lies on the south slope of the Erzgebirge (Metal Mountains) of Bohemia, in a ravine

History.

running north and south. Mining began there, in all probability, during the first years of the sixteenth century. In 1517 the number of miners was 8,000 and the town counted 20,000 souls. It was in 1518 that the first silver crowns were struck here. They were at first called *Joachimsthaler*, afterwards, by abbreviation, *Thaler*, whence also *dollar*.

Depressing effect of the wars of the 17th century.

The wars of the seventeenth century had a highly prejudicial effect upon the exploitation, which declined to such an extent that the annual production sank rapidly from a mean of 22,000 kilos of silver during the first 80 years to an average of 3,000 kilos, at which it remained from 1595 to 1877.

Geological occurrence of the metalliferous veins.

The vein-bearing rocks of Joachimsthal are mica schists inclosed by granite. The veins in the eastern portion of the mine, where there are masses of included limestone, carry calcite as the gangue mineral. Those in the western part of the mine are quartzose, and are accompanied in part by masses of included porphyry. There are seventeen veins which strike north and seventeen which strike east. It is a remarkable fact that those which strike north show enrichment where they pass or cross the intruded limestone or porphyry, while the other set of veins are not thus affected. The width of the veins varies from two meters down. They have been explored to a depth of 520 meters and to a horizontal distance of from 1,500 to 4,000 meters.

Nature of the ores.

The ores raised carry silver, cobalt, nickel, bismuth, and

Workings.

uranium. There are four shafts, the deepest being 533 meters. The drainage is accomplished by the aid of two

tunnels, with a united length of 40 kilos. About 600,000 kilos of ore are raised yearly. AUSTRIA-HUNGARY.

Compared with those of other mines the ores raised at Joachimsthal seldom require stamping. The ore is concentrated on Rittinger's percussion tables. The result is 4,000 kilos of concentrations, containing from 0.1 to 0.5 per cent. silver, 5 to 6 per cent. cobalt and nickel, and 8 per cent. bismuth; and, farther, 2,500 kilos of uranium concentrations, containing 24 to 30 per cent. of uranoso-uranic oxide. Joachimsthal. Concentration of ores.

The concentrations containing silver, etc., are shipped to Freiberg. The uranium ores are delivered to the local factory, where they are converted into pigments much employed in glass and porcelain coloring. The production of colors amounts to 4,500 kilos yearly, and samples were exhibited in Paris. As a subsidiary product vanadates are also prepared and were exhibited. Destination of the silver and uranium ores. Production of colors.

Idria. Idria.

Idria, in Carniola, lies above twenty miles east of north from Trieste. The deposit of cinnabar at Idria was discovered between 1490 and 1497. Position.

Recent investigations of the geology of Idria by the present manager, M. Lipold, have proved that the ore-bearing rocks are exclusively Triassic, and that the Carboniferous sandstones and schists which form the roof of the metalliferous Triassic beds have assumed this abnormal position only by dislocation, displacement, or reversal. Geological occurrence of the cinnabar.

The direction of the principal fracture of dislocation can be studied above ground. It runs from northwest to southeast for a long distance, and is encountered again in one of the principal faults of the mines, and in the extensive fractures and folds of the metalliferous *Wengen* beds which occur in the northern part of the mine.

The nature of the deposit is very different here and in the southeast portion. While in the former the deposit is inclosed in the Upper Triassic Wengen beds, which are calcareous conglomerates and dolomitic breccia, and there assumes the form of a segregation or of a bedded vein, in the southeast the ore is contained in limestone and dolomite belonging to the Lower Triassic. Here it occurs especially in transverse fissures filled with schistose limestone and impregnated with cinnabar. This impregnation is observed even in the country rock, in which it occurs in remunerative quantities. The richest ores assume a lenticular shape, and are found in the Wengen beds in the northwest. Their appearance has carved for them the names of "steel ore" Geological association of the deposit.

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(Stahlerz), "liver ore" (Lebererz), and "brick ore" (Ziegelerz). They sometimes contain as much as 40 per cent. of quicksilver.

Idria.

Workings. The workable region at Idria is 300 meters deep, 800 meters long, and from 20 to 60 meters thick. At the end of 1877 there were 925,800 cubic meters of rock in sight, with a contents of 32,580,000 kilos of quicksilver. The cubic meter of rock in place gives an average of 2,600 kilos of roasting ore, with a contents of 1.35 per cent. quicksilver.

Winning. Winning the ore is accomplished by "cross-cut work," a modification of pillar and stall work, involving filling, which is applied to thick seams on ore bodies of great dip and feeble tenacity. Drifts are run at various levels in the ore body, and cross-cuts are run at intervals to foot and hanging wall. The pillars thus formed are won in from the cross-cuts toward the center, and from the walls of the deposit toward the central drift, by side stopes or stalls. To sustain the roof, timbers are set and immediately packed. After the whole level has been stoped out in this way the ore immediately overlying the exhausted stopes is opened

Filling. out and won in the same manner. The filling is obtained from workings driven for prospecting purposes, from the barren rock won with the ore, or if necessary is even sent

Sorting in the mine. down from the surface. The ore is divided in the mine into roasting ore, sorting ore, and waste.

Exploitation. There are five shafts, varying in depth from 100 to 307 meters. The hoisting engines are for the most part hydraulic. The tramways under ground measure 4,000 meters, those above ground 2,900 meters.

Annual production. The mean annual production is 1,800 metrical tons roasting ore and 28,200 tons of ore requiring sorting; or, in all, 30,000 tons, with a contents of 500 tons of quicksilver.

Sorting at the works. Hand-picking of the poor rock was substituted in 1842 for a primitive wet dressing. The ores raised are dumped into a screen which separates the coarse stuff from the fine. What does not go through the screen is carried to a sorting house, where it is classified into high grade, low grade, crushing ore, and waste. What goes through the first screen falls into a second and finer screen. What goes through the second screen is delivered to the smelting works direct, and the comparatively small stuff which does not pass the second screen is sorted. The ore, high grade or low, is

Stamps. crushed dry in a 25-stamp battery, and afterwards delivered to the reduction works separately.

Blake crusher. The finer ores are reduced in a Blake crusher, then sifted,

Sorting table. and the coarse stuff sorted on a revolving sorting table into

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ore and waste. The contents of the various classes of ore is from 0.4 per cent. to 50 per cent.

Idria.

The methods employed in the extraction of the quicksilver from the ores have varied greatly since the mine was first worked. At first open vessels were used,* afterwards earthen pots, for which cast-iron receivers were substituted in 1641. These receivers at first approximated to the form of jars; in 1665 they were made as retorts. It was at this time that the method of heating the cinnabar with lime was invented. In 1750 the Almaden furnace was introduced. In 1787 the horizontal furnace, called the Idria furnace, with a chimney and condensation chambers, was built.

Retorting.

Lime process.

Furnaces.

The great quadruple furnace called the Leopold, and erected in 1825, was derived from the last mentioned. It was at work till 1870. The Alberti reverberatory furnaces date from 1842. They are provided with inclined condensation pipes, cooled by sprinkling with cold water. In 1869 lime kilns were adopted as a type, and two cupola furnaces provided with condensation chambers were erected. This system was perfected in 1870 by M. Exeli, manager of the works and the inventor of the "iron-clad furnaces." At the same period reverberatory muffle furnaces with 8 muffles were constructed for the treatment of the rich ores. In 1871 these furnaces were replaced by the two muffle furnaces now in operation. Since 1875 the reduction of the ores of both high and low grade has also been accomplished by the help of long reverberatory furnaces of the type in use in lead works for roasting purposes (*Fortschauflüng-söfen*).

Leopold furnace.

Alberti furnace.

Exeli's iron-clad furnace.

Muffle furnaces.

Reverberatories.

The reduction of cinnabar in muffle furnaces is effected by decomposition of the sulphide by caustic lime. In all the other furnaces it is simply a process of roasting and distillation.

Processes of reduction of cinnabar.

A system of flues of a total length of 706 meters stands in connection with a high stack placed at the summit of the mountain, through which the gases escape, leaving the quicksilver behind.

Fume flue.

The following is a list of the furnaces in use:

List of furnaces in use.

Alberti reverberatory furnaces, heated through the bottoms, condensation in forked pipes	10
Roasting furnace, with bottom heat and condensation in forked pipes	1

* The "*Notice*" says *meules ouvertes*. I suppose this to refer to the *tertia ratio* described by Agricola. Open vessels of ore were placed in a tight room over furnaces heated from the outside. To promote condensation green boughs were placed in the inclosed space. The quicksilver gathered on the floor and the leaves.

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Idria.

Furnaces.

Cupola furnaces, condensation in forked pipes..... 2
Iron-clad furnaces, the stack heated with wood, condensation in crockery pipes 3
Muffle furnaces..... 6

Ore production. In a run of eleven months the works can reduce 13,000 tons of ore in lumps, 20,000 tons of gravelly ore, and 2,000 to 3,000 tons of pulverized ore.

Loss. The loss has been determined during the last years at 13.58 per cent.

Vermilion. Vermilion is manufactured on a large scale at Idria. The process is very old, but satisfactory, and consists—

Process. 1st. In the preparation of æthiops by intimate mixture of mercury and sulphur.

2d. Transformation into cinnabar by distillation.

3d. Conversion of cinnabar into vermilion by grinding and washing.

Production. Sixty tons of quicksilver are annually converted into vermilion in this way, with a loss of 0.35 per cent. of metal.

Workmen. The workmen employed at Idria number 1,040, of whom 602 are occupied in the mine, 65 in the ore-picking houses, 195 in the smelting works, and the remainder in various shops.

Wages and benefits. Besides their wages, which are small, the miners receive grain and fuel at a fixed price, and when ill are provided with medical attendance and medicine free of charge. There are also government lodgings for the employés. The mutual insurance association possesses a fund of 78,000 florins, and disposes of a hospital. The mine supports a school for the children of the miners.

Cinnabar exhibit of Idria. Idria exhibited cinnabar in its various associations and specimens illustrating the geology of the mine; also characteristic fossils of the important beds, very necessary to the proof of so extraordinary a fact as the occurrence of the Triassic under the Carboniferous. The various vermilion colors and the intermediate products in their manufacture were also displayed:

Product of Idria smelting works.

Product of the Idria Smelting Works.

Years.	Length of run, in months.	Quicksilver.	Artificial cinnabar.
		Kilos.	*Kilos.*
1860	Nine	166,346	78,117
1865	Ten	169,329	100,811
1870	Twelve	370,690	98,819
1871	Ten	375,789	33,605
1872	Eleven	383,495	66,498
1873	do	377,387	46,963
1874	do	372,135	48,041
1875	do	369,729	58,064
1876	do	372,413	49,265
1877	Ten and a half	380,200	64,080

AUSTRIA-HUNGARY.

Schneeberg.

Schneeberg.

Another mine mentioned by the *Notice*, and which also exhibited in Paris, is worthy of mention because of its exceptional character and its considerable commercial importance.

Position.

The Schneeberg (Snow Mountain) lies about 30 miles southwest of Innsbruck, and forms the intersection of several lofty ranges. Near its summit, 2,200 meters above sea-level, and just below the glacier limits, is the Schneeberg zinc-blende mine.

History

Everything leads to the belief that this mine was worked as far back as the middle of the fifteenth century—not for blende, of course, but for argentiferous galena and chalcopyrite. In 1486 a thousand miners were at work; but soon afterwards the ore was practically exhausted.

Formerly worked for argentiferous galena.

Reopened for blende.

In 1868 and 1869 new examinations of this mine led to its reopening for the sake of the zinc blende found in untouched veins, and also in the ancient pack and on the dumps.

Geological occurrence of the metalliferous deposits.

The deposits occur in micaceous schists, which constitute the rock of the range to which the Schneeberg belongs. They are from 2 to 17 meters thick, and consist of blende, galena, and a little iron and copper pyrites. Ankerite, calcite, quartz, garnet, and amphibole, in part in fibrous varieties, accompany the ores. The strike is northeast, the dip 29° to 38° northwest, and the deposits have been followed 2,200 meters in strike and to a depth of 987 meters. The veins are repeatedly faulted.

Workings.

The underground work has thus far been confined to general exploration and preparatory arrangements. Extraction on the outcroppings, on the other hand, has made great progress, and large quantities of blende are now obtained.

Concentration works.

There are three concentration works connected with the mine—two of them close to it, the third at Meiern. On account of the altitude, the works at the mine can only run four months in the year; the establishment at Meiern nine months. The difficulty of exporting the ore is excessive.

Production.

The Schneeberg Mine, with its ore-dressing works, is now turning out about 7,000 tons of blende, with a mean zinc contents of nearly 45 per cent.,* besides over 3,000 tons of dressed galena. It is expected that this product will be doubled or trebled when the projected preliminary work is completed.

Schneeberg exhibited maps and ores.

* This would give over 3,000 tons zinc. Great Britain produced 6,834 tons of that metal in 1877

X.

ITALY.

Interesting exhibit of Malfidano zinc mines and Roccatederighi copper mines.

While the Italian exhibit was in many respects interesting, the explanatory information presented cannot be said to have been altogether satisfactory. The important mines of Sardinia were well described in a pamphlet issued by the Malfidano Company, and two other mines of comparatively small importance, the lignite mine of Murlo and the copper mine of Roccatederighi, both in Tuscany, pursued a similar course. But the lead and iron industries were represented only by specimens of products, and the information given in the *Catalogo Generale Sezione Italiana* was of the most meager description. The following fragmentary account of the mining industry of Italy must therefore suffice.

Inadequate exhibit of lead and iron industries.

Large exportation of ores in consequence of the absence of coal.

An important part of the mineral industry of Italy * is reflected in the exportation, because in the absence of important deposits of coal the smelting of ores in the kingdom is much limited. The principal exportation of ores during the year 1877 was as follows:

Exportation.

	Tons.
Iron ores	236,667
Copper ores	9,616
Lead ores	27,531
Zinc ores	78,255
Manganese ores	7,375
Sulphur ores	210,327

Carrara marble quarries.

The quarries of Carrara also represent an annual production of about 140,000 tons of marble, which is in great part worked up in the country before exportation.

Salt.

Government monopoly.

Salt is produced both by government works and by private industry. The government, which has a monopoly in all the continental provinces, derives therefrom an income of 80,000,000 of francs yearly, and has nine salt works in operation.

Rock-salt and maritime evaporating works.

These are in part rock-salt mines and in part evaporating works on the coast, and produced from 2,500 to 150,000 tons.

Manganiferous iron.

Manganiferous pig, in part for use in the manufacture of Bessemer steel, is indeed produced, but the whole product is only 30,000 tons per year. Including the reworking of scrap-iron, the production of bar-iron amounts to 50,000

* *Catalogo Generale.*

tons. The importation of iron exceeds 200,000 tons annually. Importation of iron.

About 300 tons of copper and 10,000 of lead are annually turned out. In the immediate neighborhood of Genoa there is a lead-refining works, and shops for the manufacture of utensils and of ornamental work in various metals are distributed over the whole kingdom. Production of copper and lead.

*Coal.**—As has already been remarked, Italy is poor in mineral fuel. Bituminous coal is found only in the province of Udine, in Sicily, and even this deposit is of no importance. Neither are the anthracite deposits of Italy of much value. The best known is in the valley of Aosta, Piedmont, from which, however, scarcely 500 tonnes (of 1,000 kilos) are yearly extracted. Lignite of Tertiary age is however more plenty. The most extensive lignite or brown-coal fields are in Tuscany, Ligmien, in the provinces Vicenza, Verona, and Bergamo, and on the island of Sardinia. The total area of these coal fields is 13,500 hectares, = 51 square miles. There are, besides, tolerably extensive deposits of peat at the foot of the Alps. Coal. Very limited supply. Lignite fields. Area. Peat.

The extent of the output of brown coal is apparent from the following figures:

	Tonnes of 1,000 kilos, 2,204 lbs.
Average of the years 1866–1870	70,000
For the year 1871	84,000
1872	95,500
1873	110,305
1874	121,855
1875	101,640

Output of lignite.

The peat product amounts to about 95,000 tonnes yearly. Peat product.

Picked specimens of fuels analyzed in the laboratory of the Royal Technical Institute in Florence gave the following results:

Analyses of lignite and peat.

Description.	Locality.	Specific gravity.	Carbon.	Hydrogen.	Oxygen.	Ash.	Units of heat.
Lignite	Montebamboli	1.32	73.44	6.15	13.20	5.10	7.485
Do	Tatti	1.66	73.10	5.88	15.89	2.50	7.220
Peat	Ghedi	.....	55.60	6.72	33.83	2.80	5.358
Prepared peat	....do	1.28	50.00	6.80	32.43	8.77	4.978

It is plain that in spite of the very moderate consumption of fuel in Italy the importation of coal must reach considerable figures.

* *J. Pechar, Kohle und Eisen.*

ITALY.

The imported coal comes almost exclusively from England, in what quantities appears in the following table:

Italian trade in coal, in tonnes of 1,000 kilos.

Table of importation and exportation of coal.

Years.	Importation.	Exportation.
1866	524,042	1,879
1867	515,943	2,068
1868	580,388	3,934
1869	653,094	6,442
1870	941,789	11,456
1871	791,589	12,550
1872	1,039,724	5,902
1873	959,532	4,189
1874	1,032,035	4,778
1875	1,059,816	7,736
1876	454,542	5,794

Iron.

Iron.—If Italy possessed coal in proportion to the quantity and quality of her iron, she would take rank with the great iron-producing countries of the world. In the absence of coal the iron industry is of little importance and advances but slowly. Smelting is effected almost exclusively with charcoal, and it is more profitable to export ore than to smelt.

Large deposits of excellent quality.

Smelting with charcoal.

Iron ores.

IRON ORES.

Table of the production, importation, and exportation, in tonnes of 1,000 kilos.

Production, importation, and exportation: 1850–1876.

Years.	Production.	Importation.	Exportation.
1850	64,000	.....	.....
1860	71,000	.....	.....
1866	145,000	392	18,110
1867	105,000	6,578	31,562
1868	102,000	6,263	24,513
1869	101,000	1	54,122
1870	74,000	1	40,711
1871	72,000	7	45,322
1872	107,000	45	168,472
1873	260,000	431	151,949
1874	265,000	12	203,397
1875	234,000	.....	191,157
1876	248,000	53	197,697

Localities of the iron mines.

Iron mines are worked in the Lombardic provinces of Bergamo, Brescia, and Como, in Sardinia, and in the Piedmontese provinces of Turin and Novara, but the most fruitful mines are those of Elba, and to them is due the credit of the greater part of the production recorded in the foregoing table. The inexhaustible iron mountain of Elba has been celebrated from the earliest times, and was worked by the Etruscans and the Romans. The ore is shipped at the harbor of Rio, in the neighborhood of which lies the Verrucano Mine, the most important in the island.

Elba.

Historical iron mountain.

Verrucano mine.

Since 1872 the production of iron ores in Italy has been tolerably large, and in the last two years the exportation

has been four-fifths of the output. The exported ore goes mainly to France, but a few ship-loads go as far as the United States. Iron ore.

Mines of Malfidano, in Sardinia.

Zinc mines of Malfidano.

The change brought about in the zinc industry by the reopening of the ancient mines of Sardinia and Greece is familiar to all who have to do with that metal, and information concerning these resuscitated mining districts will be welcome to many. Accordingly, a large part of the *Notia*, published by the Zinc Mining Company of Malfidano, is here reproduced. Ancient mine.

The deposits worked by the Malfidano Company are of two general descriptions. For the most part they partake of the character of bedded veins. This is the case at Malfidano, at Genna-Arenas, and at Planu-Sartu. But sometimes they are masses or chimneys of ore, which appear to bear no relation to the stratification of the inclosing limestones, except that they preserve the same dip, which is more or less nearly vertical, as at Planedda and at Monte-Rexio. The limestones are supposed to be Silurian. Character of the metalliferous veins worked by the company.

The most important of these deposits is that of Malfidano, which contains calamine, blende, galena, and cerusite. These minerals are mingled without any order in the deposit. Calamine, however, predominates and constitutes seven-eighths of the whole. The deposits at Malfidano.

The deposit of Malfidano takes the form of an immense vein, parallel to the stratification of the limestones. Its limits have not yet been precisely determined.

This vein appears to have two branches. In the more important of them the calamine is generally distributed in masses or chimneys, which are parallel to the limestone beds. These chimneys or masses of ore exhibit very variable horizontal dimensions, and sometimes attain a thickness of twenty meters. When several of them unite, as is not infrequent, the ore is developed in the general direction of the deposit for a hundred meters, or even more. Elsewhere the calamine is distributed more regularly in veins of varying thickness. In both modes of distribution the ore follows the general dip. Distribution of the calamine vein.

It is in this branch of the vein that the mine of Malfidano, properly so called, is situated. The other branch contains few workable deposits.

The deposit at Planedda has the form of an inverted truncated cone, the larger base reaching the surface, where it presents an area of about 1,200 square meters. At 60 me- Deposit at Planedda.

ITALY.

Zinc mines of Malfidano.

ters from the surface the area is about 110 square meters, below which there is no ore of any importance. This mass seems to have been nearly worked out. The ore is princi-

Mine at Planedda.

pally earthy calamine, but of remarkably constant composition, carrying from 39 to 43 per cent. of zinc.

Monte-Rexio mine.

In the deposit of Monte-Rexio are found various concentrations of calamine, occurring in masses of varying size in dolomite limestones. The mass bearing the name "*De la Route*," is the most important; it measures 100 meters by 30, and has been explored for 50 meters in depth without reach-

Character of the deposit.

ing its inferior limit. It consists, for the most part, of white calamine, which is nearly pure carbonate, and of yellowish calamine covered with crystals of zinc silicate. The ore is mixed with lime-spar ferruginous matter, containing a small amount of zinc. The ore of this mine, like that of Planedda, contains little or no metallic sulphides.

Genna-Arenas mine.

The Genna-Arenas Mine, to the west of Monte-Rexio, has not been worked to any great extent. It consists of lenticular bodies, sometimes isolated and sometimes connected by veins of calamine.

Planu-Sartu mine.

The Planu-Sartu claim contains two deposits, distinguished as the north and south bodies. Next to Malfidano the south body is the most important and richest of the deposits belonging to the company, and it is the most regular of all. Its general strike is north 25° east, and its croppings extend for 340 meters, and are from 40 to 50 meters wide.

Character of the deposit.

At the surface the ore forms a series of lenticular bodies, arranged like a string of beads, and were very profitably worked. But in depth the walls of these ore bodies approached each other, whence it was believed that the deposit of the Planu-Sartu would give out. But explorations by shafts proved that below the croppings there are veins of considerable thickness and great regularity, such as are seldom found in deposits of calamine. All these veins are parallel to the limestone beds in which they are situated, and are remarkable for their continuity in depth. Five of these veins have been discovered, and their thickness varies from 1.5 meters to 5 meters. At some points they open out to a greater width, and one of these enlargements reaches 12 meters. The character of the ore of this mine is very varied. The color is white, yellow, red, and black, and the texture varies as greatly as the color.

The north body is parallel to and analogous to the south body, but carries comparatively little ore.

Exploitation.

Exploitation.—The mines of the Malfidano Company seem to be exceptionally well situated for working, for a large

Zinc mines of Malfidano.

part of the ore lies at or near the surface, while at the same time the topography is such that tunnels can be run into the ore bodies. Hence, the deposits can, for the most part, be worked as open casts, and the material dumped through chutes to the tunnels, through which it is brought to the surface nearly at sea-level. Underground workings of the ordinary character are also necessary in a few places. There is little trouble with water.

Workings.

Classification of ores.

Production of ore.—The ores extracted are divided into two great classes, lump ore and earthy ore. The latter come almost exclusively from Planedda and Planu-Satu. The production of lump ores, from the organization of the company, has been as follows:

Production of lump ore.

	Tonnes.	
1866–'67	28,753	1866–1877.
1868	35,967	
1869	33,968	
1870	16,287	
1871	15,290	
1872	26,878	
1873	29,073	
1874	31,459	
1875	35,119	
1876	42,364	
1877	45,598	
Total	340,756	

In addition, there have been produced, during the same period, 59,102 tons of earthy ore sufficiently rich for sale. An ore-dressing works is being constructed at Buggerru for the treatment of a couple of hundred thousand tons of low-grade ore now on hand, and will go into operation at the end of 1878.

Works for dressing earthy ore.

Besides the ore above mentioned, 21,250 tons of zinco-plumbiferous ore has been sorted out from the products of the mines. The following is given as the mean composition of the ore actually extracted from the Malfidano Mine:

Zinco-plumbiferous ore

	Per cent.	
Carbonic acid and combined water	26.40	Analysis.
Zinc	40.00	
Oxygen	10.06	
Silicic acid	5.00	
Lead	5.54	
Ferric oxide and aluminum	6.50	
Lime and magnesia	4.40	
Sulphur	2.00	
Total	99.90	

This composition is nearly the average of the ores from the various mines, which contain from 38 to 45 per cent. of

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Zinc mines of Malfidano.

zinc. The earthy ores are of a similar composition. The zinco-plumbiferous ores contain 34.50 per cent. zinc, 20.50 per cent. lead, and 150 grams of silver per ton of ore.

Analysis.

Exploitation.

These latter, as well as the earthy calamines, are sold raw, while the lump ores of zinc are roasted at Buggerru, with charcoal, in shaft furnaces 6 meters high and 3 meters in diameter at the widest point.

Calcining.

The calcining increases the zinc contents of the ore to 54.40 per cent., and it is said that the variation in the composition of the roasted calamine does not amount to 1 per cent.

Workmen.

The number of workmen employed by the company is 1,465.

XI.

SPAIN.

Grand natural resources in lead, quicksilver, copper, iron,

So far as natural resources are concerned, Spain is one of the first mining countries in the world. It leads all countries in the amount of lead and quicksilver produced; the copper-mining district of Huelva is one of the most important in Europe; the iron mines of Bilbao are as famous for the quantity of their ores as for the quality of the metal produced from them; its coal fields are extensive and have the advantage of lying near the sea-coast; and ores of zinc and other metals abound. The exhibits made at Paris, however, as far as Class 43 isc oncerned, were utterly unsatisfactory, some of the most famous mines not even being represented by specimens of ore, and information either as to the mining statistics of the country or as to the nature and workings of particular deposits was conspicuous only by its absence.

coal and zinc.

Inadequate exhibit in Paris.

Under these circumstances the Commissioners would be justified in omitting any report upon the Spanish exhibit, but Spain plays a part really so important, and potentially so much more so, in the mining industries of Europe, that a few facts gleaned from various authors are here set down.

The following *résumé* of the product of the metallic mines of Spain is taken from a work by M. Denis de Lagarde:

Report of Denis de Lagarde.

Production of ores in Spain.

Production of ores in Spain: 1867–1869.

Ores.	1867.	1868.	1869.
	Tonnes.	*Tonnes.*	*Tonnes.*
Lead	337,093	317,670	278,374
Argentiferous lead	30,417	28,908	33,440
Silver	1,648	3,404	2,931
Argentiferous pyrites	25	500	1,825
Copper	237,488	227,732	306,620
Argentiferous copper	110	95	223
Zinc	86,822	131,407	113,485
Nickel and cobalt	122	1	83

While no trustworthy figures are attainable for the product of the Spanish mines since 1869, it is known that the figures of the above table have undergone considerable modification. The amount of lead and zinc produced has diminished, while that of copper has largely increased.

The chief lead-mining province of Spain is Murcia, on the southeastern coast, which produces two-thirds of the yearly output. The province of Santander, on the Bay of Biscay,

The lead mines of Murcia.

SPAIN.

in Old Castile, leads in the production of zinc, but the province of Murcia stands next to it, and the two together produce nine-tenths of the total zinc product of the country.

Zinc mines of Santander and Murcia.

Copper.

Almost all the copper is produced in Huelva, which lies in the southwestern corner of Spain, adjoining the great pyrites-mining district of Portugal.

Iron ore.

Iron ore is largely mined both in the Bay of Biscay, in the neighborhood of Bilbao,

Coal.

and in the southeast (Murcia), while coal comes chiefly from Asturias and Palencia, on the northern coast, but also from Cordova, in the south.

The following notes are mostly taken from M. J. Pechar's valuable treatise, *Kohle und Eisen in allen Laendern der Erde:*

Cause of the inadequate prosecution of coal mining.

Spain possesses such important deposits of coal that the entirely inadequate prosecution of coal mining would be very remarkable were it not fully explained by the unfavorable political conditions of the country.

Extent of Spanish coal fields.

The extent of the coal fields of Spain is estimated at 906,720 hectares (nearly 3,500 square miles). The store of coal is supposed to be from 3,000 to 3,500 million of tons. Of this two-thirds can certainly be mined with profit, and at the present rate of consumption (a million and a half of tons a year) would last Spain for 1,300 years.

History of coal mining in Spain.

Coal mining in Spain was begun about the middle of the eighteenth century, but in 1825, on the promulgation of a new mining law, there was no coal being mined. Since that time there has been a very gradual rise in the production and consumption. But more than half the amount used is still imported, as will be seen by the following table:

Statistics of Spanish coal mines and workings.

	Provinces.	Extent of coal properties being worked.	Number of workmen employed.	Steam-engines.		Product.
				Number.	Horse-power.	
Coal.	TRUE COAL.	*Acres.*				*Tonnes.*
	Oviedo	51,874	3,883	6	144	374,914
	Cordova	1,769	1,066	14	272	176,336
	Palencia	3,341	1,540	8	97	119,259
	Sevilla	94	120	3	95	13,500
	Gerona	748	42	1	50	6,880
	Leon	995	39	.....	.....	4,721
	Burgos	408	48	.....	.....	220
	Total	59,229	6,738	32	658	695,340
Lignite.	LIGNITE.					
	Barcelona	4,605	165	1	10	7,516
	Santander	198	66	.....	.....	2,022
	Guipuzcoa	304	12	.....	.....	1,584
	Teruel	1,047	77	....	.....	1,157
	Logroño	124	10	.....	.....	243
	Alicante	119	12	.....	.....	208
	Balearic Isles	282	51	.....	.....	200

SPAIN.

Statistics of coal industry.

Provinces.	Extent of coal properties being worked.	Number of workmen employed.	Steam-engines.		Product.
			Number.	Horse-power.	
LIGNITE.	*Acres.*				*Tonnes.*
Navarra	30	4	.....	.....	200
Gerona	277	34	.....	.....	140
Oviedo	259	29	.....	.....	56
Castellon	272	27	.....	.....	20
Total	7,517	587	1	10	13,346
Aggregate	66,746	7,325	33	659	708,686

Production, importation, consumption: 1860–1877.

Years.	Production.			Importation.	Consumption.
	True coal.	Lignite.	Total.		
	Tonnes.	*Tonnes.*	*Tonnes.*	*Tonnes.*	*Tonnes.*
1860	320,899	18,952	339,857	452,479	792,330
1865	461,396	34,359	495,755	394,806	890,561
1870	621,832	40,095	661,027	566,011	1,228,838
1871	589,707	43,824	633,531	534,897	1,168,428
1872	687,791	33,460	721,251	592,567	1,313,818
1873	658,744	20,938	679,682	619,248	1,298,930
1874	695,340	13,346	708,686	580,708	1,289,394
1875	628,810	25,689	654,499	704,287	1,358,786
1876	675,926	30,888	706,814	774,770	1,481,584
1877	699,500	.....	.....	837,053	1,536,553

Comparative consumption for various purposes.

In the report on England an interesting table was given showing the purposes for which the coal raised was consumed. The consumption in Spain from 1872 to 1874 for various purposes was as follows:

	Tonnes.	Per cent.
Mineral industries	500,000	38.6
Railways	190,000	14.7
Illuminating gas	110,000	8.5
Navy	28,000	2.2
Merchant marine	110,000	8.5
Various industries in Catalonia	146,000	11.3
Various industries in other provinces	216,000	16.2
Total	1,300,000	100.0

Convenient position of the coal fields.

It is by no means impossible that the coal fields of Spain may hereafter be developed to an enormous extent. What gives them an especial value is that many of them lie close to the coast—an advantage shared in Europe only by the coal mines in Wales and the north of England. Spain is therefore in a position to supply with coal the countries lying about the Mediterranean, most of which are poorly off for mineral fuel, and to ship it through the Suez Canal to Asia. The first object must, however, be to supply the home consumption, for which purpose the output will have to be more than doubled.

SPAIN.

Coal.

Consideration of the hindrances to efficient exploitation.

What are the difficulties which have hitherto stood in the way of and still prevent the development of the coal fields? They are lack of capital, and of enterprise, and of facilities for transportation. When the legislation of Spain permits the association of capital; when, in general, the domestic conditions of the country have improved; when a system of railways has been developed; and when the managers of the railroads better understand the purposes for which carrying companies are founded, then no doubt mining in Spain will flourish in proportion to its mineral resources.

Iron ores.

The rich and important beds of iron ores.

The great wealth of Spain in the best of iron ores is well known. The Spanish deposits of the finest carbonate and oxide ores are among the most important in Europe. Under other domestic conditions Spain, possessing extensive coal fields, might compete with England in the iron industry. Up to the year 1873 the output of iron ores made great progress; in 1874, partly in consequence of the Carlist war, the production sank to one-half. No doubt the panic of 1873 in the commercial circles of all countries was also influential in the same direction.

Fluctuations in the output.

Political disturbances.

The following are a few data as to the production and exportation of iron ore, which cannot be extended for want of data. The unit is the metrical tonne of 1,000 kilos, or 2,205 lbs.:

Production and exportation of iron ores:

	Years.	Production.	Exportation.
1871–1877.	1871	585,762	391,436
	1872	781,468	745,802
	1873	811,926	800,381
	1874	402,952	.....
	1875	496,528	.....
	1876	908,899	.....
	1877	1,162,170	.....

In 1877 the production of iron ore was distributed as follows:

Production by provinces.

	Tonnes.
Biscaya	702,090
Murcia	200,000
Oviedo	59,400
Other provinces	200,680
Total	1,162,170

Analyses.

The following analyses of Biscayan iron ore were made in the laboratory of El Carmen Iron Works, at Baracaldo, near Bilbao. Under the term *vena dulce* is understood the purest red hematite; *campanil* is also red hematite, which

for the most part contains limestone, and is especially sought for export, *mineral rubio* is brown iron ore:

	Vena dulce.		Campanil.			Mineral rubio.	
	1.	2.	1.	2.	3.	1.	2.
Iron oxide	86.26	80.78	80.75	84.01	73.90	79.14	83.75
Silica	1.35	2.63	3.24	3.20	5.70	7.20	5.25
Alumina	1.53	1.38	3.10	0.40	3.80	2.40	3.20
Manganic oxide	1.78	2.24	8.15	4.38	5.80	2.45	3.17
Lime	9.27	6.39	0.82	0.40	0.45	2.23	1.36
Magnesia	Trace.	0.46	1.04	0.80	1.25	0.71	Trace.
Sulphur	....	....	....	....	....	Trace.	0.04
Phosphorus	....	....	....	....	....	....	....
Water, etc	3.81	6.12	2.90	6.81	1.25	5.27	3.23
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Metallic iron	.....	.....	56.52	58.80	51.73	55.40	58.62

XII.

PORTUGAL.

The following information is derived from articles published in the special catalogue of the exhibit of Portugal.

Geological character of the country.

Almost all the known geological formations are found in Portugal. One-third of its area is composed of igneous rocks, such as granites, diorites, porphyries, and basalts; a second third of the more ancient sedimentary formations, schists, grauwackes, and crystalline limestones.

Granites predominate at the north of the country and toward the center, syenites and diorites are more frequent to the south of the Tagus, and the porphyritic rocks are found almost exclusively at the center of Alemtéjo, in the southern portion of the kingdom, while the basalts occur to the north of Lisbon. The schistose rocks of the Archæan, Silurian, and Devonian formations occupy the remainder of the north and of the center, as well as of nearly the whole of the southern portion of the country. The Secondary beds constitute nearly the whole of the zone comprised between Aveiro and Lisbon, the mountains of Arrabida, and the shores of Algarve, the southernmost province of Portugal. Finally, the Tertiary and alluvial deposits cover a large area towards the center, and are found disseminated throughout the country. A great number of metalliferous veins, generally forming distinct groups, traverse these formations.

Ancient working of metalliferous deposits.

Many of the important ore deposits of Portugal were worked by the ancients, who left numerous traces of their operations. Mining, however, was for a long time utterly neglected, and may be said to have recommenced in our own days. Until 1820 the mines were considered as national property, and the ownership was vested exclusively in the government, but at the initiation of the constitutional system this monopoly was abolished, and private individuals were permitted to work the mines upon payment of an annual tax of five per cent. upon the product. This state of things continued until the close of 1852, when the law now in force was enacted.

Abolition of government monopoly in mines.

The mining laws.

The fundamental principle of this law is that mines are state property. Under it the discoverer of a metalliferous deposit or one of mineral fuel can record and enter on possession of a claim in spite of any opposition on the part

Mining laws.

Respective rights of discoverers of metalliferous deposits, and of the proprietors of the land.

Patents.

Obligations of the miner claimant.

Taxes.

of the proprietor of the surface; the latter is, however, entitled to full damages and to a royalty. It is obligatory upon the claimant, within six months after his claim has been inspected by a government official and pronounced legitimate, to begin active operations, otherwise the title is forfeited. A patent is granted in perpetuity, but the property must remain undivided, and must be continuously worked. Furthermore, the workings must be kept in a safe condition, and a tax of five per cent. on the net revenue is collected. Half of this tax is paid to the proprietor of the soil as royalty. A further tax is levied, amounting to $89 per 10,000 square fathoms.* The taxes collected form a special fund, to be applied in such ways as the government sees fit to the advantage of the mining industry. These taxes are not collected for two years after the patent is granted. Ores are subject to no export duties.

Concessions in force in 1878.

On the 1st January, 1878, there were 276 concessions for mining enterprises in force.

Mineral districts.

The kingdom is divided into four mineral districts, and a mining engineer is attached to each in the quality of inspector. It is his duty to see that the provisions of the mining law are enforced.

Iron.

Iron.—All provinces of the kingdom abound in iron ores, and each of the various ores of this metal is found in workable quantities. They are found in veins in the schists of Alemtéjo and among the Secondary rocks to the south of Leiria, where they are accompanied by beds of lignites.

Lead.

Lead.—Lead mines also abound, although many of them, supposed to be susceptible of great development, produce, as yet, but little ore. The most important seem to be the mines of Mertola, near the Guadiana. These contain galena yielding seventy per cent. of lead and from five hundred to six hundred grams of silver per ton. The carbonates which accompany the galena are sometimes still more argentiferous. Lead sulphate, crystallized and amorphous, also accompanies the ores. Sometimes tetrahedrite accompanies lead ores, which then carry from 950 to 1,000 grams in silver per ton.

Argentiferous galena, etc.

Copper.

Copper.—The principal copper mines are in the Evora district, where a considerable number of veins are found in granites and porphyries. Another important deposit is that of Palhal, in Aveiro.

The great metalliferous district of the Spanish province

*The Portuguese fathom is 86.56 inches English, and the above area is nearly 12 acres.

PORTUGAL.

of Huelva also extends into Portugal, and great bodies of

Copper.

cupreous pyrites are found in Saint Domingos, Aljustral, and Grandola.

Tin.

Tin.—Tin is found in the granites near Porto and elsewhere, and as fluvial deposits in a large number of localities, but in small quantities.

Zinc.

Zinc.—Zinc is represented in Portugal chiefly by blende, found in association with galena. Blendes occur which are so argentiferous as to be classed with silver ores.

Portugal possesses also mines of manganese, antimony, nickel, cobalt, and silver.

Anthracite.

There are seams of anthracite near the Devonian schists of the mountains of Vallengo and of Bussaco, as well as a certain amount of Carboniferous territory to the southeast

Lignite.

of Alcacer do Sal. There are also Jurassic lignites to the south of Leira and in the mountains of Buarcos. The coal mines, however, are not worked steadily, as they are scarcely profitable, though the coal is of good quality.

Salt.

Salt.—There are no less than 1,200 salt marshes on the

Production.

coast of Portugal, and their product is estimated at 22,000,000 hectoliters. In 1866 246,000 tonnes, worth 1,400,000 fr., were exported.

Quarries.

There are over 800 quarries in Portugal, yielding marble, granites, slates, clays, sand, etc.

The mining industry of Portugal, while it is not unimportant, is subject to great fluctuations.

The following is the mean annual production of the Portuguese mines for the periods named:

Mean annual production of metals and coal: 1851–1872.

Ores.	1851–1860.		1861–1870.		1871–1872.	
	Tonnes.	Value in francs.	Tonnes.	Value in francs.	Tonnes.	Value in francs.
Cupreous pyrites	8,956	300,000	235,840	7,005,000	146,894	4,333,000
Copper	1,235	309,000	4,227	1,022,000	1,892	459,000
Lead	950	211,000	2,931	638,000	2,213	488,000
Antimony	60	17,000	164	50,000	19	5,500
Tin	12	17,000	7	17,000	.....	.....
Coal	15,462	372,000	19,002	578,000	12,387	305,000
Manganese	.....	.....	8,832	611,000	14,226	1,226,000
Argentiferous zinc	.....	.....	16	2,000	.....	.....
Nickel	.....	.....	5	2,000	.....	.....
Silver	.....	.....	1.2	500	.....	.....
Iron pyrites	4	.....	23	500	.....	.....
Iron	.....	.....	1,340	17,000	2,423	26,000
Total	26,679	1,226,000	272,388.2	9,942,000	180,054	6,833,500

Table showing the exportation of Portuguese ores. PORTUGAL.

Years.	Lead.		Copper.		Tin.		Exportation of ores:
	Tonnes.	Value in francs.	Tonnes.	Value in francs.	Tonnes.	Value in francs.	
1866			915	6,969,844			1866–1876.
1867	239	72,472	111,873	5,471,233			
1868	951	136,972	85,693	4,398,383			
1869	2,516	883,022	140,739	7,011,494			
1870	1,039	237,938	274,363	9,178,966	10	14,861	
1871	2,328	316,788	117,667	5,673,705	129	30,477	
1872	1,593	249,466	181,690	9,077,688	91	43,361	
1873	1,408	260,305	222,025	11,027,777	57	91,872	
1874	1,127	308,316	168,054	8,275,722	28	26,005	
1875	863	278,550	167,776	8,809,155	33	16,494	
1876	1,289	456,744	61,773	3,115,200	58	21,577	

Years.	Iron and manganese.		Phosphate of lime.		Exportation of phosphate of lime:
	Tonnes.	Value in francs.	Tonnes.	Value in francs.	
1866	619	59,533	7	36,427	1866–1876.
1867	1,809	103,616	48	4,083	
1868	5,223	496,500	469	23,161	
1869	12,994	442,661	72	12,500	
1870	14,428	650,872	408	17,027	
1871	4,442	217,616			
1872	21,444	1,424,388	1,817	97,344	
1873	30,945	1,303,316	154	8,555	
1874	35,009	1,216,450	357	11,300	
1875	43,822	787,572	4,479	164,355	
1876	21,509	559,505	2,902	76,550	

The consumption of metals in Portugal was as follows in the years named: Consumption of metals:

Metals.	1873.	1874.	1875.	1873–1875.
Steel.....tonnes..	988	1,020	1,100	
Antimony.....do..	11	1	5	
Quicksilver.....do..	16	23	21	
Lead.....do....	362	393	324	
Copper.....do....	240	274	157	
Tin.....do....	76	94	63	
Iron.....do..	24,933	22,634	28,333	
Tin-plate.....do..	1,139	1,143	1,267	
Brass.....do....	324	234	227	
Zinc.....do....	165	145	236	
Gold.....grams..	73,597	88,700	89,500	
Platinum.....do....	4,789	2,280	101,115	
Silver.....do....	223,877	94,760	172,430	

The following table gives the exportation of crude and manufactured metals from Portugal: Exportation of metals:

Metals.	1873.	1874.	1875.	1873–1875.
Steel.....tonnes..	92	135	114	
Lead.....do....	54	29	149	
Copper.....do....	51	194	272	
Tin.....do....	1	.....	13	
Iron.....do..	1,665	1,210	1,713	
Tin-plate.....do....	3	.....	11	
Brass.....do...	96	96	35	
Quicksilver.....do....	.....	4	.....	
Zinc.....do....	.....	2	.....	
Gold.....grams..	145,910	22,252	23,848	
Silver.....do....	2,552,808	2,624,509	498,096	

PORTUGAL.

Pyrites mine of Saint Domingos.

The direction of the mine of Saint Domingos presented at the Exposition a pamphlet containing a very graphic account of the difficulties encountered and of the work accomplished at that important mining locality. As is well known, the enormously developed pyrites industry of Great Britain largely depends upon material from this mine. Besides the interest which the description derives from these facts, it will be refreshing to some readers to turn from the statistics which enter so largely into the present series of papers to an account of the industrial and social conditions under which mining enterprises are carried on in Europe, so curiously different as they are from those prevailing in the United States. Almost the whole of the *Notice sur la mine de pyrite curieuse de S. Domingos* is therefore here translated.

Mine of Saint Domingos.

Geographical position of the mine.

In the midst of an arid and rocky country, at a distance of about nine miles from the Guadiana River and of nearly thirty miles from the sea, is situated the cupreous pyrites mine of Saint Domingos, in Portugal. It lies in the *concelho* or commune of Mertola (Mytilis Julia of the Romans), belonging to the administrative district of Lower Alemtéjo, the chief town of which is Breja.

Geological description.

Geological sketch.—The geognostic character of this part of the country is almost identical with that of the metalliferous district of the province of Huelva, in Spain. Here, as in the neighborhood of the deposits of pyrites of Tharsis and Rio-Tinto, as at Aljustrel, and at Grandola, which form a sort of prolongation of the same zone towards the west, the metamorphism of the schistose rocks is very pronounced. For a long time this part of the country was classified as belonging to the Devonian period, and the rocks about the mine were considered as completely Azoic. The investigations which M. Nery Delgardo, a Portuguese geologist of the highest merit, has recently made, lead to the conclusion that the zone just spoken of belongs to the Silurian epoch, and shows perfectly distinct traces of organic fossils. In a very interesting paper which M. Delgardo presented to the Royal Society at Lisbon, he set forth the reasons which have led him to consider these rocks as a formation by themselves, having no connection with the other geological regions of the peninsula. From examination of the casts of fossils which he has found in the course of his researches, and of the geological phenomena the traces of which he has studied and compared in detail, M. Nery Delgardo draws inductions equally ingenious and plausible, which enable us

Nery Delgardo.

Deductions from the paleontological examination of the formation.

Mine of Saint Domingos.

to follow step by step in their geological succession the vicissitudes which this part of the terrestrial crust has undergone at the remotest period of the earth's history.

The succinct nature of a notice like the present scarcely permits of our drawing more largely, as we should be truly pleased to do, upon geological and paleontological dissertations which form the matter of M. Nery Delgardo's memoirs.

Its geological character.

Overlying the sahlbands which limit the mass of pyrites, as well as in the barren country rock which formerly covered it, are found, among argillaceous schists, the croppings of which predominate everywhere, silicates, grauwackes, and numerous quartzose veins, which the metamorphism of the subsoil has given rise to among micaceous or talcose schists, the whole being covered with detritus. From the decomposition of these rocks there has been formed a clay impregnated with hydrated oxide of iron of a reddish color and a variable hardness, which envelops the pyritous ore body of Saint Domingos.

Mineralogical character.

Mineralogical character.—This mine, although inclosed in schists, does not take the form of a vein or exhibit a banded structure; it may be classed rather as a bedded mass, the axis of which is nearly horizontal. Its outline might be called navicular, or boat-shaped, for it is six hundred meters in length and sixty meters wide, and thins out in all directions.

The strike of the deposit is very nearly W. N. W. and E. S. E. In its general character it offers many points of resemblance to the pyritous masses of the same kind in Germany and Upper Italy.

Analysis.

The ore is a cupreous pyrites of iron. It contains, by dry assay, an average of 2.75 per cent. of copper and 45 to 50 per cent. of sulphur, accompanied by sulphides of iron and the other compounds which are generally found in the analysis of pyrites of a similar nature.

Archæology.

Archæology.—At the mine of Saint Domingos, as well as at the others in the same district, and at those of Tharsis and Rio-Tinto, in Spain, plain evidences of extensive operations by the Romans are met with, as well as vestiges—though somewhat indistinct—of still more ancient workings, which have been ascribed to the Phenicians or the Carthaginians. What has given rise to this supposition is, among other things, a marked difference in the degree to which the raw material has been exploited. This difference has been observed between the upper beds of the slag dumps left by the ancient miners about the mine and the underlying slags.

Evidences of Roman and still more ancient workings.

PORTUGAL.

Pyrites mine of Saint Domingos.

However this may be, the Roman workings, as is proved by the coins found in the course of the excavations, took place at the period between the latter portion of the reign of Augustus or the succession of Tiberius and the partition of the Roman Empire under Theodosius, a period of about three centuries and a half. The vestiges found of a settlement also date, in all probability, to this epoch, and are numerous and interesting. There have been found, in the center of the excavations, foundations and other remains of habitations, pedestals and fragments of columns, the latter, however, in small number and without artistic finish. There have also been found along the valley into which the drainage tunnel opens, rows of sarcophagi, covered with flags of the local schist, placed at small depth, and still containing bones, which fell to dust on coming into contact with the air. In later excavations have been found vestiges of the cremation of bodies, the ashes being inclosed in little urns; others, still smaller, are evidently what are called lachrymal urns. Besides these objects a great quantity of pottery has been exhumed, for the most part in fragments. It is greatly to be regretted that the awkwardness of the workmen employed in the excavations has prevented the recovery of these precious relics of the past in good condition.

Evidences of the Roman workings.

Remains of habitations.

Sarcophagi.

Urns.

Pottery.

Among the relics of mining operations the most remarkable are unquestionably the great wooden wheels which were found, like those in the mines of Tharsis, in a state of perfect preservation,* and which were used in pumping out water. These wheels, to the number of ten, are furnished with buckets upon their circumferences. Eight of them were 16 feet in diameter and two others were 12 feet.

Ancient norias.

The adits which the ancients drove to drain the mines have answered the purposes of the modern exploitation after having been suitably enlarged. The Roman workings reach a depth of 66 feet below this gallery in places. Being in search only of rich ores they left standing what seemed to them of low grade. As a consequence, their workings are very irregular, a fact which has caused the modern company great inconvenience and excessive cost in retimbering.

Ancient adits.

Present workings.—The mine is worked on levels, of which there are at present three. The first is opened at a depth of 40 feet, the second is 52 feet lower, and the third is 80 feet below the second. The upper two levels are now uncovered by the removal of the barren ground overlying the

Present workings.

* As is well known, the absence of decay in the wood found in these mines is due to the presence of cupric sulphate, formed by the natural decomposition of the pyrites.—G. F. B.

Pyrites mine of Saint Domingos.

deposit. The principal galleries are driven as nearly as possible parallel to the axis of the deposit and in contact with the north and south sahlbands. The other excavations particularly conform to the method of winning in "by cross-cutting," and extend from one drift to the other for nearly the whole distance. Two levels below those just mentioned are now being opened up. Formerly there were, besides, a number of shafts sunk from the surface vertically upon the ore deposit, which were employed for the extraction of the ore. The working of the mine having been undertaken as an open cast, as will presently be seen, these shafts successively disappeared by the removal of the ground through which they passed. There remain only those portions which were sunk in ore; these serve to ventilate the lower workings and maintain direct communication between the different levels.

The workings.

Sizes of excavations.

The principal excavations in the ore body are of the following dimensions:

Drifts, 6 ft. 6 in. × 6 ft. 6 in. to 24 ft. × 26 ft.

Cross-cuts, 6 ft. × 3 ft. 9 in. to 13 ft. × 20 ft.

The apparently excessive size of some of the drifts, especially in the upper levels, was unavoidable on account of the frequent occurrence of ancient excavations, which it was necessary to unite by arched passages of 23 ft. to 26 ft. in height, for safety in working.

The dimensions of the shafts below the timbering are ordinarily 7 ft. 4 in. × 3 ft. 8 in. in those portions which pass through solid overlying rock, and 6 ft. 7 in. × 8 ft. 3 in. in the ore.

Estimated quantity of pyrites extracted up to 1877.

The quantity of pyrites extracted from the mines from the first workings to the end of the year 1877 is shown by the following figures: Ancient excavations, estimated approximately at 150,000 cubic meters; modern excavations, 659,671 cubic meters; total, 809,671 cubic meters, or about 3,578,745 tons English.

Contract system of breaking ground.

Breaking ground in is performed under contract, on a system which has long been usual in the peninsula. The miners are paid so much per cubic meter, and the price includes the cost of tools, powder, dynamite, and other necessary materials, which are furnished the miners by the company at cost price. The manufacture and repair of tools is provided for on the spot, and the smiths are paid a fixed sum for making each implement. These mechanics are employed exclusively in working for the miners, and the labor is at their cost, while the fuel, the anvils, and all the forge-fittings are furnished by the company.

PORTUGAL.

Pyrites mine of Saint Domingos.

Removal of the whole overlying deposits.

The ore body laid bare.

System of working.

Product up to 1877.

Cost.

Extraction of the ore.

Mine locomotives.

Inclined planes.

In order to diminish the cost and facilitate the execution of winning in, to enable the complete extraction of the ore with a minimum of danger to the men, and above all to attain an increased rapidity in the workings and a larger output, the removal of the overlying material was undertaken in the year 1867. This barren ground had an average thickness of 32 meters. The project was put in execution as soon as conceived, with the approbation of the Portuguese Government, the liberality and good will of which, it should be said, has greatly facilitated the execution of enterprises on a large scale. This work is already considerably advanced, and has produced very perceptible results in diminishing the cost of the winning in of ore. The greater portion of the deposit is now laid bare. The position of the ore body, which forms, so to speak, the core of a hill rising in nearly equal slopes from the surrounding valleys, has made the execution of the cuttings much easier. After the removal of the surface an excavation was first made in the center of the high ground. Tunnels were then run from the bottom of this excavation to the external slopes of the hill. These tunnels were run on a grade sloping outwards, and were made of sufficient size to accommodate locomotives and cars. Through them the remaining material forming the wall of the crater-like pit was removed. A system of such tunnels was established on each of the several levels upon which the removal of the barren rock was undertaken.

The amount of material received in this way up to the end of 1877 reaches the large figure of 2,488,824 cubic meters. The work has cost £225,000 sterling. The enormous mass of earth removed has nearly filled up the valleys surrounding the mine.

Extraction of the ore.—The ore was formerly drawn out by mules, but this operation is now effected entirely by steam-power. For this purpose tunnels have been pierced from the mine to the slopes of the hill, with a downward grade toward the outer end. The upper tunnel, which serves to extract the ores from the open cuttings and the nearest underground workings, has a grade of only 5 per cent. Transportation was effected by locomotives of 30 horse-power. The timbering of this tunnel having been destroyed by fire, and the ground about it having been considerably disturbed, it was considered prudent to remove the overlying ground and convert it into an open roadway. In the removal of the pyrites obtained from the lower levels the ore has to surmount an incline of 30 per cent., and transportation is effected by buggies or cars drawn by a wire

rope, which is attached to a fixed steam-engine of 90 effective horse-power, set at a distance of 180 meters from the mouth of the tunnel. This engine operates a drum of large diameter, about which the iron rope passes. Steel ropes have of late been substituted for iron. Another engine on the same plan is now being set up to answer the demands of the increasing output from the lower levels. A third engine is employed in pumping the water from the mines, the pump being single-acting and of large diameter. The pumping rods rest on cast-iron rollers fixed at the top of tall wooden trestles. In preparation for the time when all mineral capable of removal by tunnels and inclined planes shall have been extracted, two shafts of large diameter have been started. They are sunk at some distance to the south of the deposit, and are designed for hoisting from any depth by means of steam-engines.

Pyrites mine of Saint Domingos.

Stationary steam engines and wire ropes

Pumping engine.

Shafts for lower levels.

Local treatment of the ore.—The problem of treating on the spot, with least possible cost, ores too poor to pay for exportation is a very difficult one to solve. This is so much the more the case as the usual plan for the treatment of pyrites includes roasting, which must naturally be carried out on a large scale. But preliminary trials on the ground aroused most energetic protests on the part of proprietors and farmers in the neighborhood, who complained of the damage done to the surrounding vegetation by the sulphurous fumes. Even the spontaneous and purely accidental kindling of certain piles of ore aroused seditious and menacing movements among the country people, and it consequently became necessary to abandon this method of treatment. Operations are hence, for the time being, limited to crushing the ores and saturating them with water from time to time. With patience and the lapse of years the copper will be extracted in a soluble condition and subsequently precipitated in tanks by cast-iron.

Local treatment of the ore.

Influence of the sulphurous fumes on neighboring vegetation.

Nature of present operations on poor ores.

Exportation.—The transportation of the pyrites from the mine to the port of shipment is performed by a railway of 3 ft. 6 in. gauge and locomotives averaging 55 horse-power. The distance is about 11 miles (17½ kilometers), but upon parts of the road the action is automatic, the grade being such that the cars descend without traction. At the bottom of the first down-grade the cars are attached to the locomotives and drawn up the ensuing up-grade, after which they descend as before. This method of transportation accomplishes a certain economy of fuel, the consumption of which is very great upon the steep up-grades.

Exportation.

Railway to the coast.

PORTUGAL.

Pyrites mine of Saint Domingos.

The construction of the railway from the mine to the shipping port on the Guadiana was accomplished in spite of serious difficulties arising from the broken and mountainous character of the country to be crossed. It was necessary either to leave slopes of 1 in 19 or to employ very powerful locomotives for the haulage of the ore, while in some places curves of 50 meters (164 ft.) radius had to be passed, rendering locomotives with a very short base essential. On the other hand, innumerable difficulties had to be overcome in conducting the traffic demanded by the exportation of the pyrites upon such a road, with freight carried amounting sometimes to 200,000 tons, or thereabout, per annum. If there be further taken into consideration the difficulties arising to the management through the excess of costs over profit, and the dearness of fuel, which has to be imported wholly from England, it will be readily seen that the transportation of the pyrites to the point of shipment is one of the largest elements in the price of our ores.

Difficulties incident to the transportation from the mines to the Guadiana.

Railway plant.

Twenty-four locomotives are in use at Saint Domingos; of these the more powerful are used on the railroad to Pomarão, and the others on the different roads within and without the mine for removing the barren material overlying the ore, etc. There are 791 cars, without counting the side-dump cars, exclusively used in terracing work. The rolling stock represents a total value of £83,342.

Ore exported.

Low-grade ores for local treatment.

The whole quantity of ore exported since the commencement of operations at the mine up to the end of 1877 amounts to 2,325,802 metrical tons. About 636,864 tons of low-grade ore have been set aside for metallurgical treatment on the spot.

Embarkation.

Embarkation.—If the construction of a railway across the country so broken as that through which the Guadiana runs was an enterprise beset with difficulties, the establishment of a shipping port for the large quantities of ore was scarcely less so. It was necessary to choose a part of the river at which a minimum distance from the mine should be combined with a sufficient depth of the channel to permit of access to steamers of deep draught. But just at the point where these advantages were combined the hills descended very steeply to the banks of the river. The creation of a port, the establishment of buildings, and the other necessary constructions here, *hoc opus, hic labor est!* Perseverance and the liberal use of capital, however, overcame the obstacles which the nature of the country offered to these plans.

Difficulty in establishing a shipping port.

The commencement was made by constructing a quay

Pyrites mine of Saint Domingos.

along which the ships were to anchor. The surface of the quay was raised to the level of the railroad from the mine. Rails were then laid to chutes in the quay, projecting to a point above the holds of the vessels to be loaded, and lined with boiler-plate. On reaching these chutes the cars are tipped on a rocker, dumping their contents directly into the vessel.

The quay on the Guadiana.

The perfect success of this arrangement has led to the construction of a second quay at a short distance from the first. By these means 1,500 to 2,000 tons can be loaded per day if necessary without much difficulty. The problem of the embarkation of ores having been solved, the next step was to build a village for the accommodation of the necessary employés, and to construct warehouses, offices, etc. For this purpose it was necessary to make cuttings in the slopes, remove rocks, fill ravines, and open up roads where there had been mere trails, accessible only to the goats and herdsmen who till then had been the sole inhabitants of these regions. At last the port of Pomarão was established, a port now well known and annually frequented by more than 400 sailing ships and steamers of a capacity of from 250 to 1,500 tons. Two tugs are kept upon the river for towing the sailing ships from the bar of the Guadiana to the port of Pomarão, a distance of 30 English miles.

Capacity of loading arrangements.

The port of Pomarão.

There are at Pomarão a large number of warehouses, offices, dwellings, etc., for the various persons to whom the shipping of the ore gives employment or business. A portion of these buildings was destroyed by the terrible flood of the Guadiana which occurred from the 6th to the 8th of December, 1876. This flood, the most disastrous of which there is any record, produced the most terrible devastation, not only at Pomarão, but along the whole course of the river. Constructions of the most solid character, which had resisted all previous inundations, failed to stand this one, and the enormous volume of waters rushing down the mountains swept the country before it in its dizzy course, leaving nothing after its passage but a vast slough, which covered a scene of fearful destruction. It need scarcely be said that Pomarão was completely demolished and had to be reconstructed. Happily, these terrible phenomena are repeated only at long intervals.

The buildings and offices at the port.

The flood of December, 1876.

Destruction of Pomarão.

On the bank of the river opposite to the shipping port a steam apparatus has been placed to draw up cars charged with ballast, which is deposited at such a height as to be safe from freshets. Grave inconvenience would otherwise be occasioned by filling up of the channel. A steam-engine of 9 nominal horse-power draws the cars up the hill by a chain.

Arrangements for deposit of ballast.

PORTUGAL.

The mine of Saint Domingos, buildings, etc.—The village known under the name of Saint Domingos was built by the company which works the mine, in the immediate neighborhood of the works. For nearly twenty centuries, ever since it was abandoned by the ancient miners, this region has been a desert, occupied only by wild beasts and an occasional goat-herd with his flock.

Village of Saint Domingos.

Description of the company's buildings.

As soon as possession was taken the construction of a village was begun, which now entirely surrounds the hill of Saint Domingos. An enormous building was erected, which contains the lodgings of the director, the offices, the laboratory, the billiard-room, and a reading-room for the recreation of the employés. The latter contains a library and the greater part of the journals of Portugal and of the principal foreign countries.

Church.

A church, dedicated to the Catholic worship, stood upon the highest point of the hill of Saint Domingos, and was in charge of a priest, whose salary was paid by the company. The enlargement of the open cast having encroached upon the site of this church, it became necessary to demolish it, after solemn deconsecration, leaving only the clock tower, which remains as a relic of the former edifice.

Religious service is now performed provisionally in a chapel which has been consecrated in another part of the company's estate, out of reach of the workings.

Hospital.

Among the buildings is a hospital, which has been established for the gratuitous treatment of the workmen, to which is attached a dispensary where medicines are furnished free of charge, the whole being under the care of a physician and an apothecary paid by the company. There

Stores.

are, moreover, a number of stores for the supply of food, etc.,

Dwellings.

and 500 dwellings more or less spacious. Of course there are various foundries, carpenter and machine shops, smithies, etc. At Saint Domingos motive power is furnished in these shops by a 16 horse-power engine. There are also spacious storehouses for the supplies of the company. There are

Workmen employed.

from 1,500 to 2,500 persons employed, according as the work is being more or less actively pushed.

For the purpose of making the works of Saint Domingos independent of the effects of the natural dryness of the country, and of supplying the needs of the constantly growing number of steam-engines, considerable capital has been invested in the construction of dams in the rivers and ravines in the surrounding country, which admit of storage of a sufficient quantity of water during the winter. The neglect of this precaution might be followed by serious con-

Storage reservoirs.

sequences, since the great heat of summer dries up all the water-courses in the neighborhood, and even the springs and wells. The largest of these reservoirs will contain from 5,000,000 to 6,000,000 cubic meters, and suffices for the supply of the boilers and of the various processes of saturation and cementation. There is even a project for the employment of the surplus water in the irrigation of lands about the mine. These lands have been acquired by the company with the intention of clearing them for the culture of such crops as are adapted to the climatic conditions of the place. The attempt has even been made to cultivate barley and oats, to serve as feed for the mules kept at the mine.

Saint Domingos mine.

Storage reservoirs.

As a hygienic measure, and for the purpose of modifying as far as possible the natural barrenness of the country, the culture of the *Eucalyptus globulus* (better known in America as the blue gum) has been undertaken in all suitable positions. This species is perfectly adapted to the climatic conditions and to the soil about the mine, and several thousand of the trees are already in a flourishing condition.

Culture of the *Eucalyptus globulus*.

The capital represented by the works, the railway, rolling stock, etc., of the mine and its dependencies may be estimated at £560,000. The general direction of the company is in London, and the ores are exported almost exclusively to England. A beginning has been made looking toward the manufacture of chemical products at Lisbon and elsewhere, but as yet only on a small scale.

Capital employed.

The managing director is Mr. James Mason, who has been successively made "Commander of the Order of Christ," "Baron of Pomarão," and "Viscount Mason of Saint Domingos" by the Portuguese Government, and has latterly been appointed "Commander of the Order of Charles the Third" by the Spanish Government. The commercial administration of the company in England, which is not less important than the able and energetic working of the mine in Portugal, devolves upon the brother-in-law of M. le Viscount de Saint Domingos, Mr. F. T. Barry, who has been elevated by the Portuguese Government to be "Commander of the Order of Christ," and promoted by a decree of November 22, 1876, to the title of "Baron de Barry."

James Mason, managing director.

F. T. Barry.

May this example excite the emulation of the Portuguese capitalists and lead them to the development of the abundant and varied resources which their country offers to their own benefit and that of the national industry. Domestic order, persevering work, and the intelligent application of capital will restore Portugal to the rank she formerly occupied among the powers of Europe.

XIII.

GREECE.

THE GREEK EXHIBIT.

The exhibits.

The exhibits illustrating the mineral industry of Greece possess a peculiar interest. The ancient mines of Attica, belonging to the most highly cultivated people of antiquity, were, unquestionably, worked with the utmost degree of technical skill the age afforded. While other ancient mines are obliterated by the weathering of the rocks or the pressure of the surrounding material, or have been worked by succeeding generations till every trace of their original character is gone, many of the mines in Attica bear every appearance of having been recently abandoned. The very tool-marks in the rock are so fresh that the form of the implements is apparent and nearly every detail of the exploitation can be followed. To a great extent we can also infer the methods of treatment of the extracted ore, from the relics hidden under piles of slag and mining waste. Few ancient writers touched upon such subjects, and if anything like technical treatises existed, which is improbable, they are lost.

Ancient mines of Attica.

Revival of ancient mining industry.

After having been abandoned for a couple of thousand years, the mineral industries of the country have been, as all know, revived, and Greece—an older mining country than Saxony or Transylvania—is a newer field for mining enterprise than Australia.

A. Cordella.

It is principally to M. A. Cordella that the public is indebted for a knowledge of the ancient and the modern mines of Greece, and from two of his publications, *La Grèce sur le Rapport Géologique et Minéralogique*, Paris, 1878, and *Le Laurium*, Marseilles, 1871, nearly all of the following information is drawn.

Geological condition of Greece.

The geology of Greece is in a very unsatisfactory condition from a technical as well as from a purely scientific standpoint. The lowest known beds of sedimentary origin are crystalline schists and saccharoid limestones. The age of these rocks is uncertain. Paleontological evidence there is next to none. M. Cordella found a single almost obliterated imprint, which seemed to him to belong to a Silurian crinoid animal. Dr. Neumayer found a Cretacean fossil (*Nerinaea*) near the foot of a tower, but was unable to find it afterwards

in the same place. Cordella believes it to have occurred in a building stone from elsewhere. Mr. Sauvage also regards these rocks as Cretaceous, arguing from analogy. The technically important point involved is evident. If these crystalline rocks are truly Cretaceous, there is hope of discovering coal below them. If they are Silurian, the coal-bearing measures are probably wanting in Greece. These rocks constitute a very large proportion of the area of the country.

Geological condition of Greece.

The strata which have been identified by tolerably preserved fossils belong exclusively to Cretaceous and later eras, especially to the Tertiary, which is well represented.

Plutonic and volcanic rocks are also largely represented in Greece and possess some technical importance.

Gold is found in some fluvial sands of Greece, as a constituent of one bed of iron pyrites in the Morea, and accompanying silver in argentiferous lead, but the known occurrences of this metal are of no economical importance.

Gold.

Silver.

Ores of the other metals obtained in Greece, particularly of argentiferous lead, of zinc, and copper, occur for the most part in the crystalline and metamorphic rocks to which reference has been made, though the granite also contains veins carrying silver as well as of manganiferous iron ores and heavy spar.

Occurrence of argentiferous lead, of zinc, and copper.

The principal mineral district is that of Laurium, at the southern extremity of Attica. Here the ores of lead and silver, of zinc, and, to a smaller extent, of copper, occur sometimes as regular veins in the micaceous schists, and occasionally in irregular bodies in the limestone, but for the most part in segregations and beds at the contact between the limestone and the schists. These strata have been broken through by recent igneous rocks, to the influence of which the formation of the ore deposits is ascribed. The deposits are of great extent, as is proved by examination of the ancient workings and prospecting shafts. Thus, at Camaresa, the center of operations of the *Société des Mines du Laurium*, one of the beds has been shown to be metalliferous over an area of about 1½ square miles. The contact deposits are from 1 to 7 meters thick, and parallel ore-bearing beds are found at different levels. Of these the ancients recognized four, and the existence of other deposits below their deepest workings has been proved. It is plain that in the absence of labor-saving machinery the ancients cannot have cared to prospect below a certain depth. The ores consist of galena, blende, lead and zinc carbonates, copper sulphides, and carbonates. Pyrites, spathic iron ore, etc., are also constituents of the deposits. In general, the main

Mines of Laurium.

Occurrence of the ores of lead, silver, and zinc.

Extent of the deposits.

Ancient workings.

Nature of the ores.

GREECE.

portion of the ore bodies consists of galena, more or less mixed with blende, the zinc carbonate occurring on the walls and in part in separate deposits. A rare mineral, adamine, a zinc olivenite, has been found at Laurium, and seems characteristic of the zinc deposits there.

Mines of Laurium.

Ancient mode of working.

The mines of Laurium were worked by the ancients with great energy, thoroughness, and skill. The ore deposits were reached by vertical and inclined shafts. Tunnels were not employed, and, according to M. Cordella, with good reason, as the dryness of the mines made tunnels unnecessary for drainage, and the topography is unfavorable to their construction. The deposits were systematically worked, the veins by stoping from one level to another, the beds by pillars and stalls. When the ore was tractable it was all removed and pillars of dry masonry substituted. Where the galena was largely mixed with blende, which was of course intractable, pillars of vein matter were left. In thick beds two floors were established, as is now often done in thick coal seams. The extraction was very complete, even metalliferous wall-rock being removed.

Masonry pillars.

Dry masonry seems to have been exclusively employed in the comparatively few cases in which the roof or walls needed support.

Tools used.

The tools used in bringing down the ore and rock appear to have been picks, bars, and sledges. In hard rock picks with conical points were used, in softer material the point was pyramidal. Contrary to Reitmaier's supposition, fire does not appear to have been employed in bringing in the rock, which is not of an appropriate character for the application of that method. Traces of the use of tools are everywhere met with, and M. Cordella has found a gad which was once iron, and still retained its shape when found, though completely oxidized.

Slave labor in carrying ore.

Transportation was effected by slaves, who carried the ore up the inclined shafts, probably in skin sacks, as is still the practice in some eastern mines. Water must have been got rid of in the same way. The steps in the inclines up which the men went are still visible, as are the niches for earthenware lamps, some of which have been found in place. The use of the perpendicular shafts is not altogether clear. From the dumps surrounding them, M. Cordella is strongly of the opinion that both the windlass and pulley were known, and that they were used to some extent for hoisting. The shafts certainly served to promote ventilation, and at the top of some of them is found, offset from the main opening, a sort of chimney, in which a fire was

Ventilating shafts.

probably built to increase the circulation of air. The shafts and inclines are nearly always rectangular and of about 4 square meters cross-section. The deepest shaft mentioned is 395 feet. None of the shafts penetrate to sea-level.

Mines of Laurium.

The ore as it was removed from the mine in ancient times was in part too poor for economical smelting, and was concentrated. Some of the concentrating apparatus, in a fair state of preservation, has been found under heaps of waste.

Ancient concentrating apparatus.

Although, as may be readily imagined, it is not possible to make out from the abandoned apparatus all the details of the process of ore-dressing as practiced by the Greeks, the main features can still be traced.

Water was scarce at Laurium and large reservoirs were built to store a supply. So solidly were they constructed that some of them might even now serve the purpose for which they were designed. The concentrating apparatus was ingeniously planned to permit the use of the same water over and over again. It consisted of a sluice some 70 feet long and provided with three sumps or wells at intervals in its length. The sluice was not straight, but made several angles in such a way that the lower end came close to the higher. Ore must have been placed at the higher end and washed with water taken by baling or otherwise from the lower end. A current was thus established, and the mixture of ore and gangue separated in virtue of the difference of specific gravity of the minerals.

Scarcity of water.

Ancient reservoirs.

Concentrating sluice.

The rich ore and the concentrations were smelted in shaft furnaces without preliminary roasting, a process for which they were very well suited, being nearly free from quartz and containing lime and iron. That the ore was not roasted is proved by the globules of fused galena found in the slags. Of the furnaces many have been found. They are of small height (our authority does not give this dimension), and about 3 feet in diameter. The fuel was wood or charcoal, and blast was supplied by bellows worked by hand. The results obtained were very fair, the slag containing from 5½ to 14 per cent. of lead. Many ancient slags found in Spain and Italy contain no less than 25 per cent. of lead.

Smelting furnace.

Fuel and blast.

Loss of lead in slag.

The furnace lead, which M. Cordella has reason to suppose averaged 0.4 per cent. of silver, or, say, $150 per ton, was refined by cupellation. The apparatus used has not been discovered, but the frequent occurrence of fused pieces of desilverized litharge proves the nature of the process.

Desilverization.

The silver was refined and the litharge reduced, and the resulting lead employed as material for weights, missiles, lamps, vases, pipes, etc.

Reduction of litharge.

GREECE.

Mines of Laurium.

The lead was assayed, and cupels of earthenware (M. Cordella merely says *de terre*) have been found in the dumps.

Assays: cupels.

They were of nearly the same form now in use, $1\frac{1}{2}$ inches in diameter, $\frac{3}{4}$ inch high, and $\frac{3}{8}$ inch deep.

Zinc accretions.

Zinc accretions formed at the tops of the ancient furnaces. They were sold for the manufacture of bronze, and, as it appears, also for use as medicine. If so, lead colic must have been familiar to the ancients, even at a distance from the mines.

Period of ancient activity 600–430 B. C.

The period of greatest activity in the Laurium mines was between 600 B. C. and the Peloponnesian war, say 170 years.

State property.

The mines were exclusively the property of the state, but they were leased to citizens in claims for long periods. The

Worked by slaves.

labor was performed by slaves, even the formen or superintendents being owned. M. Cordella estimates the number of workmen employed at Laurium at about 15,000. This was a vast body of slaves to handle, and must have required very strict organization. During the Peloponnesian war

Revolt.

Laurium was cut off from the capital and the slaves revolted. It is very easy to see that the re-establishment of the workings on the only possible basis of slave labor must have been a matter of great difficulty in the troubled times which followed, and a knowledge of these circumstances sufficiently

Subsequent workings on a small scale.

accounts for the historical fact that the mines were afterwards worked fitfully and with little energy, operations being sometimes confined to the resmelting of old slags, an enterprise which might evidently be conducted with small capital or permanent stake in the prosperity of the district. The mines were worked to some extent under the Romans,

Abandoned 1st century of the Christian era.

but through Greek factors. In the first century of the Christian era Laurium was completely abandoned and became once more the haunt of wild beasts. There is no evidence that work was ever recommenced until the present generation.

Enormous extent of ancient workings.

The amount of work done in the Laurium mines was enormous. Some 2,000 shafts have been found, averaging about 250 feet in depth, and the extent of the subterranean

Slag of former operations.

workings is vast. The quantity of slag found is about 2,000,000 tons, and M. Cordella shows that this slag must have represented 2,100,000 tons of lead and 8,400,000 kilos of silver, or, say, 345,000,000 of dollars. The whole period of 700 years during which operations were going on at Laurium M. Cordella regards as equivalent to about 300 years of active work.

Mining laws of 1861.

The modern development of the mineral industries of Greece dates from the promulgation of mining laws in 1861.

These laws were founded upon those embraced in the French legislation of 1810 on the same subject. Since this time many persons have boldly undertaken mining enterprises, and the country has been prospected foot by foot. Many economically valuable deposits have been discovered. Some of them are being worked, others are waiting for the capital necessary to develop them. It was at this period that the *Société Hilarion, Roux and Co.* was formed. This company undertook in 1864 the resmelting of the plumbiferous slags of Laurium, and in 1869 the smelting of the ancient mining waste.

Société Hilarion, Roux & Co.

Resumption of work at Laurium.

Prodigious excitement followed upon the results obtained by this company. Claims were taken up by the hundred all over the kingdom on deposits of lead, zinc, copper, iron, manganese, chromium, lignite, and sulphur. Of course time proved the fallaciousness of many hopes and the necessity for patience and capital, and the inevitable process of weeding out has followed. A portion of the more hopeful enterprises have attracted the support of foreign capital.

Mining excitement.

The want of acquaintance on the part of the public in Greece with the conditions of industrial enterprises, and the lack till lately of Greeks possessing any professional acquaintance with mining or smelting, have been calamitous to the mineral industries of Greece. For a long time commissioners visited Laurium at short intervals to find the gold bars and the hidden sources of supply of the bullion turned out by the smelting works. That this was the legitimate result of the treatment of ores and slags was not credited. Then, by a sudden change in popular sentiment the contents of the material at Laurium was as much overvalued as it had previously been undervalued, and taxes were placed upon the working amounting to more than half the worth of the output. The Hilarion Company was obliged to sell out, their successors and many others were nearly or quite ruined, and affairs reached such a pass that the interference of foreign governments had to be called in for the protection of the rights of those of their subjects who had ventured to attempt the development of industry among a people whose tone of mind was so little congenial to it.

Ignorance of the Greek public,

and of Greek officials.

Ruin of the companies by unjust taxation.

Interference of foreign governments.

Of late years an essential change for the better has come about. Numbers of young Greeks have studied mining at the great schools of Europe, and returned to Greece. More equitable arrangements as to imposts have been made, and *La Société des Usines du Laurium* seems to be in a flourishing condition.

Change for the better.

GREECE.

This company smelts ancient slag and mining waste and such lead ores as are now raised in the district. It possesses a mechanical ore-dressing establishment, where 300 tons of waste, containing 5 to 6 per cent. lead, are treated per diem, yielding 50 tons of concentrations. The remainder of the waste is concentrated at the ancient dumps in hand-jigs. The smelting works contain 7 Pilz furnaces. Plumbiferous iron ore is used as flux, and 12 per cent. of coke is burned. The annual product is 7,000 to 7,500 tons of lead, with $40 to $70 per ton in silver, and about 400 tons of speiss, containing 20 to 22 per cent. copper and 2 per cent. nickel, besides lead, arsenic, etc. The amount of fume caught in a condensation flue 1,200 meters long is from 1,200 to 1,500 tons.

Mines of Laurium.

Present works.

Plant.

Product.

The mines of Laurium are also being worked with vigor by the *Compagnie Française des Mines du Laurium*, which began operations at the close of 1875. Calamine (carbonate), blende, and lead ores are raised. A portion of the calamine is roasted. The following are the results which have been obtained by this company,* in tons of 1,000 kilos:

French company of the Laurium mines.

Calamine, blende, and lead ores.

Product.

	1876.	1877.	Half of 1878.
Raw calamine	1,166	2,425	3,006
Roasted calamine	4,810	18,477	10,104
Blende	.....	340	119
Lead ores	.....	432	507

The calamine of Laurium is richer than that of Sardinia, which is said to average about 33 per cent. The mean contents of the roasted calamine for each year was as follows:

Analysis of roasted calamine.

	Per cent. zinc.
1876	40.081
1877	51.30
1878, above	60

The last steamer-load was settled for on a basis of 65.585 per cent. zinc. There is a large amount of calamine in sight, and the boast seems justified that this is the most important output of calamine in the world. The zinc ore is sent to Anvers and Swansea.

Zinc ore sent to Anvers and Swansea.

Blende and galena separating works.

The lead ore raised is mostly mixed with blende, and the company has built an ore-dressing works to separate the two. The galena is very rich, much of it running over $90 to the ton of lead.

Other metalliferous deposits.

There are numerous other deposits of ores in Greece, not only of lead and zinc, but of copper, iron, and sulphur.

* *Note sur les Mines de la Com. Fran. des Mines du Laurium.* Lithographed.

GREECE.

Many of these have been prospected, and even worked. Thus, 45,000 tons of iron ore have been extracted at Serephos, and smelted in England with results highly satisfactory so far as the metal was concerned. In the eparchy of Phthiotide two copper mines of a very promising character have been opened, and in the island of Milo sulphur is actually being extracted to some extent, but the unwise policy of the Greek Government until a recent date, the general badness of the times, and the recent protracted wars on the Greek frontier have prevented active exploitation. Greece, however, promises much in the near future.

Iron ore.

Copper.

Sulphur.

No true coal in Greece.

Lignite.

No true coal is known to exist in Greece. The coal and coke annually imported from England amount to 76,000 tons. Lignite, however, occurs over large areas, estimated at some 1,200 square miles. This lignite is of very fair quality, and is easily mined. Its heating effect is much less than that of English coal, and it takes from 125 to 150 parts of the native product to do the work of 100 parts of the imported fuel. About 6,000 tons were mined in 1877.

Character of the exhibit in Paris.

Models of ancient ore-dressing apparatus.

The exhibits made by Greece were of a highly interesting character, and illustrative of the facts set forth in the foregoing pages. The ores, ancient slags, and mining waste found at Laurium were shown, and M. Cordella presented models of the simple and ingenious ore-dressing apparatus in use when Rome was struggling into notoriety. The story of Laurium is certainly one of the most romantic chapters in the history of technology. The genius of Athens may fairly be said to have mastered the difficulties presented, but the conquest was dependent on unnatural economical conditions, and was consequently temporary. The hold which modern science has taken on the subterranean treasures of Attica will not be so easily shaken off.

XIV.

THE DUTCH EAST INDIES.

THE DUTCH EXHIBIT.

Scarcity of minerals in Holland.

Holland produces no valuable minerals, unless a certain quantity of dredged peat may be so considered. The Dutch possessions in the East Indies, on the other hand, lie in a remarkable mineral belt, extending from the mainland through the peninsula of Malacca into the Malayan Archipelago. This region furnished the only important supply of tin, besides the mines of Cornwall and Devonshire, until the recent discoveries in Australia. Banca tin, too, is renowned for its great purity. Gold, gems, and coal also occur, and occasionally in remunerative quantities.

The rich mineral belt of the Dutch East Indies.

Banca tin.

The mineral resources of the Dutch Indies are not yet thoroughly investigated, and there seems a probability of considerable increase in their productiveness. It is only within a few years that the Billiton mines began to put tin upon the market in considerable quantities, causing a sudden depression in the price of that metal, a harbinger of the greater disturbance caused by the discovery of immense deposits in Australia. New tin fields have since been found, and bid fair to become important.

Billiton tin mines.

Exploitation by Chinese.

All work connected with the exploitation and treatment of tin ores is performed by Chinese. Formerly agents were appointed to encourage their emigration, but at present they present themselves in sufficient numbers. They work in companies, under contract, receiving a fixed price for tin delivered, and enjoying some privileges in the matter of supplies. European engineers exercise a certain amount of control and supervision.

Exhibit of R. H. Arntzenius.

The exhibit of M. R. H. Arntzenius, manager of the Billiton Company, and the collective exhibits of the products of the Dutch Indies, gave very full and interesting information as to the methods, instruments, and apparatus employed, as well as of the products obtained, the mode of life of the miners, etc.

Cornelius de Groot's account of the Netherlands mining industries in the East Indies.

M. Cornelius de Groot, who was formerly at the head of the Department of Mines in the Dutch East Indies, prepared, at the request of the members of the jury, a short account of the mining and metallurgical industries of Banca, Billiton, and the other islands belonging to the Netherlands. As

the subject has considerable commercial and professional interest, while but few papers on the subject have been published excepting in Dutch technical journals rarely seen in America, some space may well be devoted here to an abstract of the above-mentioned essay. Some supplementary information will be properly accredited. NETHERLANDS.

The island of Banca. Banca.

Geological description. The sedimentary rocks are argillaceous and quartzose sandstones, etc., belonging to the Lower Devonian (Grauwacke). The crystalline rocks are, for the most part, granite, to some extent diorite, and rarely griesen and schists. The remaining formations are of Quaternary origin, and it is in these that the tin ore, "stream-tin," occurs. Veins containing tin ore occur in Banca, and the griesen is sometimes impregnated with tin-stone, but the mineral is for the most part found in reticulated veins (stockwerke), associated with quartz.

Occurrence of the stream-tin.

Occurrence of the tin-bearing gravels. The tin-bearing gravels of the island are found in ancient or recent valleys, and deposited in one of three ways: disseminated through the surface stratum to the depth of nine feet or more; disseminated through several beds, one above the other. These beds consist, besides the stream-tin, of but little-worn fragments of quartz and feldspar, sand, etc. Finally, the tin-stone is found disseminated through quicksands which rest upon the bed-rock. The latter is sometimes granite, but oftener kaolin, or, in other words, granite in a highly advanced stage of decomposition.

Chinese prospecting apparatus. In prospecting for tin-stone a small Chinese boring apparatus called Tsjam is employed. This apparatus* consists of an iron rod over 20 feet long and 1 inch thick, to the lower end of which is attached by its side a conical tube of a few inches in length, open at both ends, and with the smaller end down. In use, the small end of the tube is stopped up by a rag, attached to a string, while sinking through superficial strata. When the bed under examination is reached, the rag is detached by pulling the string, and the tube fills with gravel. To determine the value of an ore-bearing stratum, a copper tube armed with a steel cutting shoe is forced through it, and a core thus removed for examination.

Open workings. The workings are all open, and not more than 8 or 9 meters in depth. After excavation the tin-stone is worked free of barren gravel.

The reduction of the ore is carried on in two different

* See *Berg- und Hüttenmännische Zeitung*, 1863, p. 338.

NETHERLANDS.

species of furnace,* one of the Chinese design, which has been in use ever since the mines were worked by Chinese, the other the construction of Dr. C. L. Vlaanderen. The Chinese furnace consists of a kettle-shaped smelting chamber, cut in a clay hearth, and connected by an open tap with an external well, into which metal and slag run together as fast as they melt. The fuel is charcoal, and the blast nozzle entering the lower portion of the smelting chamber is directed downward upon the bottom of the chamber to keep it hot. The slag is resmelted once or twice, besides being crushed and washed. The blast is produced by piston blast engines worked by hand.

Tin-reduction furnace.

Chinese furnace.

Vlaanderen's furnace.

Vlaanderen's furnace is a small open-top blast furnace, run with a fan blast. The height is somewhat over 5 feet, and the cross-section nearly square and 2 feet 3 inches from front to back. There are three tuyeres, which are so placed that the jets of blast cross each other. The fuel used is charcoal, and lime is added as a flux. The "glass" is thrown into water and subsequently re-smelted with more lime. Tungsten, which is however rare in Banca, is reduced in the comparatively hot Vlaanderen furnace. The furnaces are run only during the night on account of the heat, the island lying nearly under the equator. Several other constructions of furnace have been tried in Banca, but with indifferent success. Furnaces of a very simple construction like those above mentioned are preferable, because they can be set up in the immediate neighborhood of the workings, and removed or abandoned as the deposits are successively exhausted. Bredemeyer† speaks of roasting the tin ore in reverberatory furnaces, and leaching out copper, etc., but of this De Groot makes no mention.

Tungsten.

Bredemeyer.

Proportion of metal in the ore.

The ore carries from 71 to 72 per cent. of pure tin. A slab of tin weighs ½ picul, or 30.8806 kilos, according to De Groot. According to a printed description of the exhibit, the weight of a slab is about 32 kilos, and Mr. R. Hunt states that 1,000 slabs weigh 32 tons, in which case a slab must weigh 32½ kilos.

Weight of tin slabs.

Government workings.

The government undertook the working of the tin deposits in 1816, employing Chinese miners and smelters, of whom the number at work at the end of the year 1876 in Banca was 7,789. The natives are known to have smelted tin fully two centuries ago, and continued to produce metal in small quantities until the Dutch Government took the matter in hand.

* See, also, *Van Diest, in Berg- und Hüttenmännische Zeitung*, 1873, p. 421.

† *San Francisco Mining and Scientific Press*, 1872, p. 470.

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The production is known since the year 1821. In that year it was 1,250 metrical tons* of tin. In the year 1846 the production exceeded 4,400 tons, and attained its maximum, 6,750 tons, in the year 1856; since then it has diminished gradually to a mean of 4,340 tons in the years 1871 to 1875, while in 1876 Banca produced but 3,932 tons.

Production of tin in 1821–1876.

Prof. G. J. Mulder analyzed Banca tin with the following results:

Analysis of Banca tin.

Lead	0.014
Iron	0.019
Copper	0.006
Impurities	0.039
Tin	99.961
	100 00

Considerable deposits of magnetite are found in the eastern part of the island. Gold is found in small quantities with the stream-tin, and sometimes in quite important quanities on the sea-beach in the district of Merawang.

Gold.

The island of Billiton.

Billiton.

The geological formation and the methods of working the ore are essentially the same as those of Banca. Stockwerke take a more important place, and are mined to some extent. Tungsten occurs in a single mine, and in another galena is met with. Copper occurs only in traces.

Geological formation.

The tin deposits in Billiton were discovered by M. De Groot, in 1851, and the workings were opened in 1853, in which year 11 tons of tin were produced (1 ton equals 1,000 kilos). In 1863 the production was 645 tons, and in 1870, 2,957 tons; for the years 1871–'75, both inclusive, annually 3,390 tons, and in 1876, 3,721 tons.

C. De Groot.

Discovery of tin deposits in 1851.

Production 1851–1876.

Dr. Vlaanderen analyzed Billiton tin, which is of the same degree of purity as Banca tin. It contains, however, about .03 of 1 per cent. of arsenic and antimony, but no copper.

Analysis of Billiton tin.

The Billiton tin mines are worked by a stock company, employing Chinese workmen.

Other tin deposits in the Dutch East Indies.

Cassiterite is found in small and not important but workable quantities in the little islands of Karimou and Singkep. A concession has been granted for working deposits of tinstone in Negri Tapong, a mountainous district in Eastern

Cassiterite in other islands.

*A metrical ton is 1,000 kilos, or 2,205 lbs.

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Tin mines in Dutch East Indies.

Sumatra, and in 1877 200 Chinese miners were at work there in three mines. A company is being formed for working these deposits on a larger scale.

Coal.

Coal is mined in the eastern and southeastern portions of Borneo. It occurs in the Lower Eocene and appears to be of a fair quality.

Diamonds.

Diamonds are found in the eastern and in the western parts of Borneo, in the detritus, but thus far not in place. Itacolumite is found with them in the detritus. They are also found not far from mountains of serpentine. No report is made of the quantity or value of the diamonds found.

Gold.

Gold is found in many parts of the Dutch Indies; in paying quantities in the interior of Sumatra and Borneo, in the north of Celebes, and on the island of Kassarouta, in the Moluccas. Platinum is found associated with gold, and with it, in some instances, ruthenium sulphide.

The quantities of Banca and Billiton tin yearly put upon the market are regularly reported in the *Mineral Statistics of Great Britain.*

XV.

BULLION PRODUCT OF THE UNITED STATES.

Little that is new to mining men in this country could be said of the United States exhibit in Class 43. Instead of any attempt to do so, the following discussion of the bullion yield, perhaps the most condensed and exhaustive which has as yet appeared, is submitted as a valuable addition to the English literature of this important subject, and as being in harmony with the tone and purpose of the preceding essays.

Bullion product of the United States, by Dr. Adolf Soetbeer.

"THE PRODUCTION OF THE PRECIOUS METALS IN THE UNITED STATES.

BY DR. ADOLF SOETBEER.

[*Petermann's Mittheilungen, Ergänzungsheft No. 57.* Translated by A. T. Becker.]

THE UNITED STATES OF AMERICA.

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Report of the Select Committee on Depreciation of Silver, Parl. Pap., London, 1876, fol., Appendix No. 8–19, No. 21, pp. 133–147.

E. Suess. Zukunft des Goldes, Wien 1877, 9, 118–157.

Report and Accompanying Documents of the United States Monetary Commission, vol. i, Washington, 1877, Appendix, pp. 1–60.

A. Del Mar. Report on Silver Production in the United States.

Bullion product of the United States.

"Two essentially different periods may be distinguished in the production of precious metals in the extensive region of country which now comprises the United States of America. They are separated by the discovery of the gold fields of California. Before the year 1849 the United States yielded perhaps less gold and silver than any other diversified region of country of the same extent. Since then the country has rapidly advanced to the foremost rank in this respect. We first meet with traces of gold-mining at the end of the last century in Virginia and South Carolina. The industry became somewhat more important between 1820 and 1840, when gold was also found in North Carolina, Georgia, Tennessee, and Alabama, and the gold obtained was coined in the newly-established mints. According to the summaries of Mr. J. D. Whitney, the gold product in the separate States from 1804 to 1850, and in the respective divisions of time, was as follows:

J. D. Whitney.

Gold production previous to 1850.

Value of gold production from 1804 to 1850.

Virginia	$1,198,600
North Carolina	6,842,900
South Carolina	818,100
Georgia	6,048,900
Tennessee and Alabama	263,800
Total	15,172,300

Value of gold production in the respective divisions of time.

1804–'23	$47,000
1824–'30	715,000
1831–'40	6,695,000
1841–'50	7,715,000
	15,172,000

Gold delivered at the eastern mints, 1851–1867.

"From 1851 to 1867 the whole amount of gold delivered at the mints in the Eastern States amounted only to $4,391,915. How insignificant this sum appears when compared with the enormous quantities of gold California and, latterly, also other States and Territories west of the Rocky Mountains have produced since 1848. It is a difficult task to ascertain even approximately the quantity of gold which has been obtained here, and all the estimates which have been made must be regarded as untrustworthy, as they vary very much from one another. They have for the most part been founded upon the export returns of San Francisco, the coinages and assays in the mints, and, above all, the books of Wells, Fargo, & Co., who have transported much the greater part of the precious metals from the various mining districts lying west of the Rocky Mountains, and keep exact accounts of the

Means for estimating the production of the region west of the Rocky Mountains.

Bullion product of the United States.

same. Such estimates cannot however be regarded as accurate, for mere opinion based on probabilities enters largely into them. A considerable part of the gold obtained by thousands of isolated gold-diggers is exported either by the owners themselves or by their friends, and does not appear on the books of the express agents or in the export returns of San Francisco. The valuations in question usually include silver. This was especially the case in former times, when the silver product was comparatively small. In many of the estimates of later years, on the contrary, a part of the gold product is reckoned with that of the valuation of the silver, especially in the product of Nevada. Moreover, it must not be forgotten that in the sum total of the aforementioned estimates gold is included which was originally obtained in British Columbia or in the mining districts of Mexico adjacent to California, and which is, therefore, not to be reckoned as the product of the United States. It also sometimes occurs that in the summary of the amounts transported the same item is twice stated. Therefore, we must allow a wide margin for errors, nor should we lose sight of the fact that the temptation to overestimate would naturally be much greater than to underestimate.

Means for estimating the quantity of gold produced west of the Rocky Mountains.

Table of the export of gold and silver from San Francisco, 1848–1863, by Richthofen.

"We will begin by giving a table of the export of gold and silver from San Francisco from 1848 to 1863, taken from the commercial publications of that city, which are based on the custom-house schedules, and are given by Mr. Blake, and also by Herr von Richthofen in the above-mentioned treatise, *Die Metall-Produktion Californiens und der angrenzenden Laender*. An addition has been made to the amounts declared during the years 1848–'59, on account of the acknowledged incompleteness of the official returns. On the other hand, for the years 1861, 1862, and 1863 a reduction has been made of, respectively, one and a half millions, six millions, and thirteen millions, on account of the silver contained in the amounts declared. The export of the latter by way of San Francisco has become of greater importance since 1861.

Years.	Declared gold export.	Estimated actual gold export.	Declared and estimated gold export from San Francisco:
1848	$66,000,000	$10,000,000	1848–1855.
1849		40,000,000	
1850		50,000,000	
1851 up to May 1	11,497,000	55,000,000	
1851	34,960,895		
1852	45,779,000	60,000,000	
1853	54,965,000	65,000,000	
1854	52,045,633	60,000,000	
1855	45,161,731	55,000,000	

Bullion product of the United States.

Gold exports from San Francisco: 1856–1863.

Years.	Declared gold export.	Estimated actual gold export.
1856	$50, 697, 434	$55, 000, 000
1857	48, 976, 692	55, 000, 000
1858	47, 548, 026	50, 000, 000
1859	47, 640, 462	50, 000, 000
1860	42, 325, 916	42, 325, 916
1861	40, 676, 758	39, 176, 758
1862	42, 561, 761	36, 061, 761
1863	46, 071, 920	33, 071, 920

Richthofen's remarks on the table.

"Richthofen elucidates his tables with the following remarks: "The gold product of California during the last few years may be estimated with considerable exactness, that produced in earlier years only approximately. The exportations three times a month per steamer via Panama, and by ship to China and other parts, serves as the basis for the statistical statements. These figures give almost the total export in gold coin and ingots during the later years, but do not include the gold remaining in the country. The amount of this latter is by no means insignificant, as in California paper money is not current and only payments in specie are accepted. Furthermore, the fact of silver being contained in the ingots of gold is not stated. But, as the average standard of gold is 0.850, this last-mentioned fact may be neglected as of small importance. Of far greater importance, however, is the fact that large sums are transmitted abroad through private individuals, and in former times even larger sums were thus exported in the form of gold-dust. In the first years the whole exportation was

Mode of making up the table.

carried on in this way. In the preceding tables is given, first, the value of the gold according to official tables, and, secondly, the value according to estimates, in which the sums exported by private individuals are allowed for. Up to 1860 the recorded export consisted entirely in gold coin and ingots of gold. In order to obtain accurate estimates for the three years 1861, 1862, and 1863, the gold contained in the bars of exported silver must be taken into consideration, as it amounts to no inconsiderable sum. This fact has been left unnoticed in the above statement in order to present a clear idea of the yield of the gold mines and gold-washings." Herr

Decrease in the California gold product.

von Richthofen further observes that the decrease in the California gold product is very noticeable when it is remembered that in former years the whole amount obtained was from the gold-washings of California alone, whereas in later years the gold mines of the whole country and the gold-washings of Idaho, Arizona, and British Columbia contributed to the sum.

Bullion product of the United States.

"The decrease in the gold yield would have been even greater were it not for the increase of the Chinese population. A white man is rarely satisfied with $4 a day, whereas the Chinese work for $1, and even less, and consequently the abandoned gold-washings could be reworked with success.

Jacoby's comments on Richthofen's estimates.

"Jacoby (*Archiv für wissenschaftliche Kunde von Russland*, B. 24) declares Herr von Richthofen's estimates to be too low; that the decrease in the export is no indication of a decrease in the product, and that the increase of the other products and exports of California is an evident cause for the retention of a much larger proportion of gold and silver in the country. It also appears unwarrantable to make no allowance for the gold which has been shipped during the past three years without declaration. The gold yield of California and the adjacent States for the years 1856–'62 may be estimated at an average of from seventy-five to eighty million dollars.

W. P. Blake's extension of Richthofen's tables.

"Mr. W. P. Blake, who has extended the above tables of the export of gold and silver for the years 1874–'76 according to the custom-house schedules of San Francisco—viz, 1864, $56,707,201; 1865, $45,308,227; 1866, $44,364,393; 1867, $44,676,292—observes further: 'Without doubt large amounts of precious metal are carried away from San Francisco by passengers in the form of gold coin and ingots. The amount thus exported is variously estimated. Commissioner Browne estimates it at about two hundred millions up to the year 1865. This estimate is, however, probably too high. Usually an addition of 10 per cent. is made to the declared amount sent from the interior for what is carried off by the gold-diggers themselves, and which does not appear on the books of the express agents.' This addition must also be regarded as too great, for it would amount to more than the sums shipped without declaration. Blake estimates the whole precious-metal export of California as follows:

Estimates of undeclared gold exported from San Francisco.

Estimate of whole precious metal export of California.

Declared export from San Francisco	$864,495,446
Undeclared export, assumed at 10 per cent. of the declared	86,449,544
Assumed to have been retained in the country	45,000,000
Total	995,944,990
Herefrom to be deducted as product of British Columbia and Mexico	35,000,000
Remains, in round numbers	961,000,000
Of this sum, according to approximate estimation, gold	807,000,000

"Before we proceed to the valuations of the entire bullion yield of the United States we will complete the above table

Bullion product of the United States.

Bullion export from San Francisco:

of the declared exports from San Francisco for the years 1868 to 1875 from published estimates by Mr. Valentine, superintendent of Wells, Fargo, & Co. Express. According to these statements the export amounted to—

1868–1875.

Valentine, of Wells, Fargo & Co.

1868	$35,444,395
1869	37,287,117
1870	32,983,140
1871	17,253,347
1872	29,330,436
1873	24,715,126
1874	30,180,632
1875	42,911,048

Bullion export: 1875–1877.

Estimate of the German consul.

"We add especial statistics of the bullion export from San Francisco during the three years 1875 to 1877 from the reports of the German consulate of that city, including the countries for which the exports are destined, as well as the nature of the same.

Export of bullion in ingots and gold-dust, in coin, and paper money.

[Paper money is included in the calculation merely in order that the sums of the two statements may agree.]

Destination.

Destination.	1875.	1876.	1877.
Export by sea to England	$173,147	$43,803	
Export by sea to China	7,652,953	10,918,967	$17,601,274
Export by sea to Panama	2,070	10,300	5,292
Export by sea to Japan	6,963	981,854	643,049
Export by sea to other countries	507,321	440,610	874,574
	8,342,454	12,395,534	19,124,189
Remitted overland to New York	34,568,594	37,384,612	38,619,462
Total	42,911,048	49,780,146	57,743,651

This total export consisted in—

Nature of the exports.

	1875.	1876.	1877.
Gold ingots	$995,019	$3,457,323	$2,209,282
Silver ingots	8,734,714	10,733,367	8,820,082
Gold coin	24,939,587	21,761,040	29,600,525
Mexican dollars	1,822,978	2,897,113	2,671,666
Gold dust	44,972	28,246	22,397
Silver coin	1,140,910	5,168,931	5,763,297
Trade dollars	4,910,859	5,734,126	8,629,345
Peruvian dollars			27,057
Paper money	21,000		
Total	42,911,048	49,780,146	57,743,651

U. S. Commissioner of Mining Statistics.

"Since the year 1867 a Commissioner of Mining Statistics, appointed by the United States Government, has held office. It is his duty to send in a yearly and circumstantial account to the Secretary of the Treasury. This report is then laid before Congress and printed. For the first two years this position was held by Mr. J. Ross Browne; after

J. Ross Browne.

him by Mr. Rossiter W. Raymond, who in the year 1877 handed in his eighth annual report (for the year 1876). These reports, which, as the author states in the preface to the last, are concluded for the present, contain a vast number of details concerning the various mining enterprises and also much technical information of all sorts. Mr. Raymond has personally inspected most of the mines in the various States and Territories and put himself in communication with a large number of persons who could give him useful information on the subject in question, and from whom he almost invariably met with the readiest assistance. In collecting the statistical information he was especially aided by the express companies. On the other hand, the circulars containing lists of queries, which were distributed, proved of little use.

Bullion product of the United States.

R. W. Raymond.

"Complete and statistically accurate accounts are given of many of the mining enterprises, but in regard to the summing up of the entire bullion yield one can readily perceive Mr. Raymond's diffidence about giving comprehensive statements as the result of his own special investigations, whereas it is precisely his estimates which have the greatest value for the public and the civil authorities. But this very reserve on the part of the author in giving general estimates, on account of the incompleteness of his materials, gives one confidence in his detailed statements. When Mr. Raymond occasionally, though with reservations, gives general estimates, they may be regarded as more authoritative than others, unless a decided reason for material deviation be given.

Value of Mr. Raymond's detailed statements.

Absence of comprehensive general estimates.

"The following tables contain the yearly reports of Mr. Raymond on the annual yield of the precious metals in the various States and Territories, and also a summary of the presumable total yearly yield of both gold and silver:

Annual yield of precious metals by States and Territories:

States and Territories.	1868.	1869.	1870.	1871.
California	$22,000,000	$22,500,000	$25,000,000	$20,000,000
Nevada	14,000,000	14,000,000	16,000,000	22,500,000
Montana	15,000,000	9,000,000	9,100,000	8,050,000
Idaho	7,000,000	7,000,000	6,000,000	5,000,000
Oregon and Washington	4,000,000	3,000,000	3,000,000	2,500,000
Arizona	500,000	1,000,000	800,000	800,000
New Mexico	250,000	500,000	500,000	500,000
Colorado and Wyoming	3,250,000	4,000,000	3,775,000	4,763,000
Utah	.....	.....	1,300,000	2,300,000
From other parts	1,000,000	500,000	525,000	250,000
Total	67,000,000	61,500,000	66,000,000	66,663,000

1868–1871.

Bullion product of the United States.

Annual yield of precious metals by States and Territories: 1872–1875.

States and Territories.	1872.	1873.	1874.	1875.
California	$19,049,098	$18,025,722	$20,300,531	$17,752,151
Nevada	25,548,801	35,254,507	35,452,233	44,478,369
Montana	6,068,339	5,178,047	3,844,722	3,573,600
Idaho	2,695,870	2,500,000	1,880,004	1,750,000
Oregon and Washington	2,000,000	1,585,784	763,605	1,246,978
Arizona	625,000	500,000	487,000	750,000
New Mexico	500,000	500,000	500,000	325,000
Colorado and Wyoming	4,761,465	4,070,263	5,188,510	5,302,810
Utah	2,445,284	3,778,200	3,911,601	3,137,688
From other parts	250,000	250,000	100,000	500,000
Total	68,943,857	71,642,523	72,428,206	74,817,596

Total bullion product of the United States:

Total bullion product of the United States.

Years.	Gold.	Silver.	Gold and silver.
1848–1875.			
1848	$10,000,000	$50,000	$10,050,000
1849	40,000,000	50,000	40,050,000
1850	50,000,000	50,000	50,050,000
1851	55,000,000	50,000	55,050,000
1852	60,000,000	50,000	60,050,000
1853	65,000,000	50,000	65,050,000
1854	60,000,000	50,000	60,050,000
1855	55,000,000	50,000	55,050,000
1856	55,000,000	50,000	55,050,000
1857	55,000,000	50,000	55,050,000
1858	50,000,000	50,000	50,050,000
1859	50,000,000	100,000	50,100,000
1860	46,000,000	150,000	46,150,000
1861	43,000,000	2,000,000	45,000,000
1862	39,200,000	4,500,000	43,700,000
1863	40,000,000	8,500,000	48,500,000
1864	46,100,000	11,000,000	57,100,000
1865	53,225,000	11,250,000	64,475,000
1866	53,500,000	10,000,000	63,500,000
1867	51,725,000	13,500,000	65,225,000
1868	48,000,000	12,000,000	60,000,000
1869	49,500,000	13,000,000	62,500,000
1870	50,000,000	16,000,000	66,000,000
1871	43,500,000	22,000,000	65,500,000
1872	36,000,000	25,750,000	61,750,000
1873	36,000,000	35,750,000	71,750,000
1874	.....	.....	72,428,206
1875	.....	.....	74,817,596

On the relative proportions of gold and silver in the sums total.

"That Mr. Raymond refrained from expressing an opinion in his latter reports in regard to the relative proportions of gold and silver in the sum total is explained by the fact that a sufficiently explicit statement had not yet been made of the gold contained in the ores of the Comstock Lode. On another occasion he estimated the silver product for 1874 at $32,800,000 and for 1875 at $41,400,000. In the material for the report of the British Parliamentary Commission Mr. Raymond's estimate in regard to the relative proportions of gold and silver in the total yield of the product for the years 1874 and 1875 is supplemented by roughly assuming the relative proportions of gold and silver in the total yield for the years 1874 and 1875 at the round sums of $40,000,000 gold and $32,000,000 silver.

"The following tables, made out by Mr. Valentine, of the presumable bullion yield in the United States from 1871 to 1876, have been published by Professor Suess:

Bullion product of the United States.

Valentine's table of the bullion yield of the United States:

Years.	Gold.	Silver.	Gold and silver.
1871	$35,900,000	$20,290,000	$56,190,000
1872	39,460,000	20,530,000	59,990,000
1873	40,460,000	28,250,000	68,710,000
1874	40,100,000	30,500,000	70,600,000
1875	41,750,000	34,040,000	75,790,000
1876	44,330,000	41,500,000	85,830,000

1871–1876.

"Mr. Raymond's reports of the annual bullion yield in the various States and Territories west of the Rocky Mountains may be complemented by extracts from the report of the German consulate at San Francisco, according to approximate valuations of the amounts of gold and silver:

Report of German consul at San Francisco.

Value of gold and silver product:

States and Territories.	1876.	1877.
California	$19,000,000	$18,174,716
Nevada	49,300,000	51,580,290
Oregon	1,200,000	1,191,997
Washington	100,000	92,226
Idaho	1,700,000	1,832,495
Montana	2,800,000	2,644,912
Utah	5,000,000	8,113,755
Arizona	1,400,000	2,388,622
New Mexico	500,000	379,010
Wyoming and Dakota	700,000	1,500,000
Colorado	7,000,000	7,913,549
Mexico	2,200,000	1,432,992
British Columbia	1,500,000	1,177,190
Total	93,000,000	98,421,754
Subtracted for Mexico and British Columbia	2,700,000	2,610,182
Bullion yield of the United States	90,300,000	95,811,572

1876–1877.

"Of this product, in 1877 ($98,421,754) about $50,000,000, or rather more than half the sum total, was gold, whereas of the yield in 1876 about $48,000,000 was gold and $45,000,000 silver. The consular report contains the following observations on the sources of these tables: 'The statements of the various mining companies regarding the yield of their mines are by no means accurate, for no one is disposed to 'show his hand,' and the artificially stimulated fluctuations of the stock market are dependent upon reports alternately hopeful and discouraging, and which have little in common with the real state of affairs. Wells, Fargo, & Co. still remain the most trustworthy authorities for the bullion yield, as the greater part of it is transported by them. In cases, too, where mere estimates only are possible, they have business connections through which they can arrive better than any one else at the correct valuation.'

Relative quantities of gold and silver: 1876–1877.

Difficulties in obtaining correct information from first parties.

Data of the Express Company the most reliable.

Bullion product of the United States.

"The whole bullion product of the United States west of the Rocky Mountains is roughly estimated as follows:

Total bullion product of the United States, west of the Rocky Mountains.

California	$1,165,200,000
Nevada	396,600,000
Oregon and Washington	44,000,000
Idaho	65,000,000
Montana	130,600,000
Utah	35,500,000
Arizona	10,300,000
Colorado	52,600,000
Wyoming and Dakota	3,100,000
New Mexico	4,600,000
Total	1,907,500,000
From British Columbia	31,200,000
From the northwest coast of Mexico	7,400,000
Aggregate	1,946,100,000

Extracts from reports of the British consul at San Francisco.

"We extract from the reports of the British consul at San Francisco some of the observations which are annexed to the tabular statements, at the same time noting the fluctuations in the price of quicksilver, as they are of great importance in the milling of silver ores, not only in the United States but also in Mexico and South America.

Report for 1872.

"*Report for the year* 1872.—Wells, Fargo, & Co. Express forwarded silver to the value of $62,000,000, and as it may be presumed that at least a quarter more found its way to San Francisco through other channels, the statisticians do not consider $80,000,000 too high an estimate for the total bullion yield of the whole country west of the Rocky Mountains. The largest part of it, however, no longer comes from California, but from Nevada, which State is credited with $25,500,000. Comparatively the greatest advance was made by Utah Territory, whose share has been variously estimated at from $4,000,000 to $10,000,000, while the Washoe Silver Mines still remain the most productive. It is worthy of note that the gold product is on the decrease, while that of silver is on the increase. The quicksilver product in California amounted to 30,306 flasks; the price ranged from 85 to 87½ cents per pound.

Report for 1874.

"*Report for the year* 1874.*—The yield of the mines in the various States and Territories is larger than that of any preceding year, partly in consequence of the extraordinary richness of many veins, partly also because, the rains having been early and plentiful, mining could be carried on longer than usual. The returns exceed those of 1873 by

*No report has been presented for the year 1873.

$2,000,000, and those of 1872 by $12,000,000. The yield consisted of gold dust and ingots to the value of $26,358,776, of silver ingots (which, however, frequently contain one-quarter part gold) to the value of $35,681,411, and of argentiferous lead ores to the value $12,360,868. Utah yields principally argentiferous lead; the gold yield of this Territory in 1874 did not exceed $100,000. Colorado ingots contain about five-eighths silver and three-eighths gold. The mines of California (with the exception of the Inyo district) and New Mexico yield almost exclusively gold. The most important event was the discovery towards the end of the year of an ore body in the Comstock Lode which appears to surpass all former discoveries in size and richness. The yield of the quicksilver mines was 34,154 flasks; the price rose from $1.20 to $1.55.

Bullion product of the United States.

Reports of the British consul at San Francisco.

Report for 1874.

"*Report for the year* 1875.—The total yield for this year may be estimated at $90,000,000; for besides the $80,889,037 which were intrusted to Wells, Fargo, & Co. as the yield of the mines in the States and Territories lying west of the Missouri, ores, gold dust, etc., were exported by other and private means. The Nevada (Comstock Lode) mines yielded $5,000,000 more than in the preceding year, in spite of the fire, which caused a suspension of work for many months, and therefore the assumption that they will yield $50,000,000 in 1875 is not unfounded. The product of the California quicksilver mines was 53,706 flasks. At the end of the year the price had sunk to 62½ cents per pound.

Report for 1875.

"*Report for the year* 1876.—Wells, Fargo, & Co. transported $75,199,541 in gold and fine silver ingots. But a large amount of bullion from the distant mines was transmitted by private means and by post to save the high express and insurance rates, and the base bullion was sent almost without exception as freight. The sum total may be pretty accurately estimated at $93,000,000. In consequence of the loss which the mine owners met with through the depreciation of silver, they lowered the wages of the miners. The yield of the quicksilver mines in the year 1876 was unusually large, and amounted to 75,074 flasks. This increased produce reduced the price of quicksilver to 55 cents per pound.

Report for 1876.

"*Report for the year* 1877.—It was supposed that the gold yield for this dry year had been as poor as the wheat harvest, as water is almost as essential for mining as for agriculture. The primitive method of washing the gold found on the surface by hand (placer mining), now falling into disuse and undertaken to any large extent only by the

Report for 1877.

Bullion product of the United States.

Chinese, is as a matter of course dependent upon rain. So, too, is the process known as the hydraulic method, in which, hill-sides are disintegrated and strata of auriferous gravel

Reports of the British consul at San Francisco.

are washed out. Jets of water issue from movable nozzles of 6 and 10 inches in diameter under tremendous pressure towards the bank which is to be demolished. This method

Report for 1877.

of mining, too, must suffer from a dry year, although the water-power is obtained from large brooks which seldom run dry. Finally, in very many of the tunnel mines proper

Apprehensions owing to scarcity of water.

water is the only motive power for the quartz mills. In consequence of all this, the natural conclusion was that the yield for 1877 would be far smaller than that of the previous year. This apprehension appears the more warrantable, because, during the year, the whole list of mining shares sunk lower and remained depreciated longer than had ever

Depreciation of mining stocks.

before been the case. It appears, however, as if there were some other ground for this continued depreciation of the stock besides the unproductiveness of the mines, and the reason is probably to be found in the fact that there was a great lack of money among the speculating public and a consequent inability to buy; for if the newly-issued reports are in any way to be credited, the bullion yield in 1877 was not inferior to that of the previous year. In California, New Mexico, Montana, British Columbia, and Mexico the total yield is, to be sure, somewhat behind that of 1876, but the difference is comparatively small. It may, therefore, be concluded that the loss caused by scarcity of water has been made good by the discovery of new mines and the enlargement of old ones, and that, had it not been for this drawback, the yield would have been far higher, as Nevada, Utah, Arizona, Oregon, Washington, Idaho, Colorado, and Dakota, where rain and snow were plentiful, have larger returns to show. These remarks are followed in the report by the detailed estimate of the probable yield, amounting to $94,421,754, which has already been given. The quicksilver product amounted to 78,600 flasks. In consequence of the low prices the production of many of the mines was intentionally reduced. A combination of the principal quicksilver mining companies succeeded in bringing the price up to 62½ cents for a short time, but the average was about 42 cents per pound.

Silver production.

"Some data respecting the silver production of the United States have already been given in connection with the gold

Up to 1859 resulted from the parting of gold.

yield for the same period. It is confessed on all sides that up to the year 1859 the silver yield of the United States arose almost exclusively from the parting of gold, and was of very

small importance. Since the discovery and opening of the rich silver mines of Nevada, however, it has obtained a much greater importance, especially since the opening of the Comstock Lode, from which within a short time such enormous quantities of silver have been produced as was never before known since the best days of the mines of Potosi and one or two Mexican mines. The silver yield of the United States seems to have reached its maximum in the years 1875–'77. But large as the yield really was, the exaggeration usual in such cases was not lacking. For this reason there was a great variation in the estimates. This was the more natural, as at that time the fluctuations in the price of silver and the extraordinary reduction of the same aroused an unusual interest in the subject.

Bullion product of the United States.

Nevada mines.

Comstock lode.

"The board of commissioners appointed by the British Parliament on the 3d of March, 1879, to investigate the cause of the depreciation of silver, give, in their report dated July 3, of the same year, a detailed account of the development of the silver produce in the United States, and especially in regard to the years 1874–'76. They also collected a quantity of material in reference to this subject, which is published in the supplement to the report. The yield of several individual mines of the Comstock Lode are given; also the quotations and dividends of many of these mining enterprises, and various other details of the same character. The general statistical statements which were submitted to them, however, vary very much from one another, and the commissioners were, therefore, unable to come to a final decision as to which of the estimates was approximately the most correct. Many of the estimates give a presumptive silver yield in the United States in the year 1876 of about $50,000,000. There was an equally large and even an increasing yield anticipated until a correspondence from San Francisco, which was published in the 'Times,' put an end to such exaggerated representations. It is here stated with authority that the silver product in the United States in the year 1876 did not exceed 24,000,000 ounces fine silver or (the ounce being reckoned at $1.15) $27,600,000.

British Parliamentary investigation on the cause of depreciation in the value of silver.

"We had intended limiting ourselves to the brief notes already given in reference to the silver produce of the United States, regardless of the fact that so great a mass of detailed reports lie before us that many pages might be filled with them; a decisive reason for this limitation, however, is the appearance of a new special official report bearing the title 'Special Report to the United States Monetary Commission on the Recent and Prospective Production of Silver in the

Special report to the U. S. Monetary Commission.

Bullion product of the United States.

United States, particularly from the Comstock Lode,' Washington, February 24, 1877. This treatise is to be found in the supplement to the report of the aforementioned Silver Commission (vol. 1, pp. 1 to 60), which appointed Mr. Del Mar to examine into the bullion product at its source, in order to do away with the universal uncertainity in regard to the amount of the same.

Report of A. Del Mar.

Explanation of previous methods of estimating the annual bullion yield.

"Mr. Del Mar first explains the methods for estimating the annual bullion yield in the United States which had been in use up to that date. The "export and consumptions method" consisted in estimating the product according to the export schedules and the amounts which had been coined during the year. The results of this method are, however, most imperfect owing to the notorious untrustworthiness and incompleteness of the export statistics.

The "exports and consumptions" method.

The "express" method.

The so-called "express method" consists in the estimates made by Mr. Valentine, superintendent of Wells, Fargo, & Co. Express, of the bullion produce of the mining district west of the Great Salt Lake, which is transported almost exclusively by this company. The ordinary statements which are published in the San Francisco papers are from this source, and are regarded by the commercial public as being more approximately accurate than the discordant published estimates; but, on the other hand, the objection is raised that considerable amounts of gold dust and ingots are brought to market from the interior without the express company being employed, and that ores which frequently contain bullion are usually sent as ordinary freight by rail, and that, therefore, in these cases Mr. Valentine is unable to do more than merely calculate the probabilities. It is also very possible that the same amount may be twice stated, which would of course unduly increase the estimate. Furthermore, the auriferous silver is stated simply as silver, and, therefore, in the declarations which have heretofore been made, the gold product is put down at too low a figure and the silver product at more than it should be.

The "bank" method.

"The 'bank method' is the estimate which is gained from a combination of the returns of three banks of San Francisco, through whose hands almost the entire silver product of California and Nevada is put upon the market. In criticising this method it was pointed out that it would be possible to gain a trustworthy estimate of the bullion yield of the United States in this way if all the assayers were obliged by law to declare the results of their assays to the Treasury, as all the gold and silver obtained in the United

States, down to trifling sums, are tested for their alloy either in the mints or by private assayers. Bullion product of the United States.

"To ascertain the bullion yield of Nevada the 'assessor's method' may also be employed. According to a law of this State, made in 1864, a yearly tax is levied on the mines of about 1 per cent. of the amount of their net proceeds, and as a check, statements of the gross proceeds must be made quarterly. Mr. Del Mar is convinced that with one or two trifling exceptions, such as the omission of the quarterly declaration on the part of small mining enterprises, and concerning the reworking of ores, the estimates of the bullion yield of Nevada gained in this way may be regarded as accurate. Report of A. Del Mar. The "assessor's" method.

"Mr. Del Mar made use of a new and independent method of valuation suggested to him by Senator Jones, president of the Silver Commission. Mr. Jones has large mining interests in Nevada, and is well acquainted with the state of affairs there. This method consists in extracting from the bullion books of the various mining companies their output. There are certain difficulties connected with this method: the number of small mining enterprises is large; the fiscal year of the various companies differs; and, finally, in early days the gold and silver yield was not entered separately upon the bullion books of many of the companies. It was possible to overcome these difficulties, however, though not without much labor. It is said, to the credit of the mining companies, that the desired information was always given with great readiness, and the tax-lists of Nevada were of service in supplementing and verifying the reports. Senator Jones method.

"On account of the insufficiency of time and assistance, these detailed and statistically comprehensive investigations could not be extended to any extent beyond the limits of Nevada up to the date of publication. That State, however, furnishes the preponderating part of the entire product. For the present only the returns for the years 1871–'76 have been given. The necessary material for the reports of the preceding years, 1861–'70, has already been extracted from the bullion books, but not yet worked up. This will, however, be done subsequently. Geographical limitation of the statement up to date of publication.

Bullion product of the United States.

"The results of Mr. Del Mar's investigations are as follows:

Result of Del Mar's investigation.

Gold and silver product of the United States.

	Districts.	1871. Gold product.	1871. Silver product.	1872. Gold product.	1872. Silver product.
1871–1872.	Comstock Lode	$4,077,427	$6,250,587	$6,310,035	$6,612,943
	Other mines in Nevada	1,485,007	7,880,764	2,142,730	9,953,634
	Whole of Nevada	5,562,434	14,111,351	8,452,765	16,566,577
	Remainder of the United States	.....	4,000,000	.....	2,000,000
	Entire silver product	.....	18,111,351	.....	18,566,577
		1873.		1874.	
1873–1874.	Comstock Lode	10,498,756	11,037,020	12,579,825	11,881,000
	Other mines in Nevada	2,673,469	8,094,440	1,650,202	3,521,382
	Whole of Nevada	13,172,225	19,131,460	14,230,027	15,402,382
	Remainder of the United States	.....	6,000,000	.....	10,000,000
	Total silver product	.....	25,131,460	.....	25,402,382
		1875.		1876.	
1875–1876.	Comstock Lode	11,739,873	14,492,350	18,002,906	20,570,078
	Other mines in Nevada	2,256,618	6,717,636	1,337,798	7,462,752
	Whole of Nevada	13,996,491	21,209,986	19,340,704	28,032,830
	Remainder of the United States	.....	9,000,000	.....	10,151,520
	Total silver product	.....	30,209,986	.....	38,184,350

Silver product of the U. S. (excepting Nevada): 1876.

"The silver product in the United States (with the exception of Nevada) is given for 1876 as follows:

Utah	$3,351,520
Colorado	3,000,000
California	1,800,000
Arizona	500,000
Montana	800,000
Idaho	300,000
New Mexico	400,000
Total, about	10,151,520

Reason for giving a variety of statements and authorities.

"The bullion yield in the United States is of such importance that it has been considered best to give in detail the principal estimates and valuations, however much they may differ from one another. From this material any one who takes an interest in the matter can form his own opinion on the subject.

Bullion product of the United States.

Dr. Soetbeer's conclusions.

RECAPITULATION.

Periods.	No. of years.	Gold product.			Silver product.		
		Total.	Yearly average.	Value.	Total.	Yearly average.	Value.
		Kilos.	*Kilos.*	*Marks.*	*Kilos.*	*Kilos.*	*Marks.*
1804-'20	17	60	3.5	9,800	.....	.....	.....
1821-'30	10	1,100	110	306,900	.....	.....	.....
1831-'40	10	8,500	850	2,371,500	.....	.....	.....
1841-'50	10	176,000	17,600	49,104,000	.....	.....	.....
1851-'55	5	444,000	88,800	247,752,000	41,500	8,300	1,494,000
1856-'60	5	385,500	77,100	215,109,000	31,000	6,200	1,116,000
1861-'65	5	333,500	66,700	186,093,000	870,000	174,000	31,320,000
1866-'70	5	380,000	76,000	212,040,000	1,505,000	301,000	54,180,000
1871-'75	5	297,500	59,500	166,005,000	2,824,000	564,800	101,664,000

TOTAL YIELD.

1821-'50	30	185,600	.....	517,824,000	5,271,500	.....	948,870,000
1851-'75	25	1,840,500	.....	5,134,995,000	.....	.....	
1821-'75	55	2,026,100	.....	5,652,819,000	.....	.....	.....

"The above table gives in German money and metrical weight, the estimates which we ourselves consider the most accurate."

JAMES D. HAGUE,
Additional Commissioner.

STEAM AND GAS ENGINES.

ANDREW J. SWEENEY.

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[Extracts from the Official Classification.]

CLASS 54.—MACHINES AND APPARATUS IN GENERAL.

* * * * * * * *

Steam-engines, boilers, steam-generators, and apparatus pertaining thereto.

Apparatus for condensing steam.

Machines set in motion by the evaporation of ether, chloroform, ammonia, or by a combination of gases.

Machines set in motion by gas, hot air, and compressed air.

* * * * * * * *

REPORT

ON

STEAM AND GAS ENGINES.

The machinery shown at the Exposition of 1878 did not exhibit many valuable improvements or new features in that department. Indeed, it was hardly to be expected that in the short space of eighteen months after the closing of the Centennial Exhibition much progress could have been made. The writer, deeming it an injury rather than a benefit to cumber reports and public documents with descriptions of work shown at previously held exhibitions, and already described, determined, as far as possible, to report only upon new features shown for the first time. This plan did not lessen the labor or diminish the time spent in examining the machinery exhibits, and in many if not in a majority of cases the time and labor so expended failed to reveal anything which could be reported upon as new. Great difficulty was experienced in the endeavor to procure descriptions, drawings, and information relating to machinery sought to be examined. Although cards were provided and left at the stands of exhibitors, explaining their object and requesting reports in its aid, the responses were very few indeed, and frequent calls failed to secure interviews with principals or with persons in charge capable of assisting in an examination. Had the Additional Commissioners been able to award medals or prizes, no doubt they would have been as fully supplied by exhibitors with information as were the members of the International Jury.

No engines of striking novelty exhibited.

Attempt to confine the report to new features shown.

Difficulty in obtaining specific information.

Among the assignments made for report were steam and gas engines and special machinery. Before entering upon descriptions, a review of the practice followed by builders of machinery of different nations in general styles, details of construction, use of devices, etc., may be valuable.

Report on details of parts of engines:

Framing.

Framing

It was almost universally found that designers had, with more or less fidelity, followed the American, or, as generally known, the Corliss patterns for beds, carrying in small en-

Corliss type.

Report on parts of engines.

gines the cylinder overhung at one end and the main shaft bearing at the other. In some cases the whole rested on pedestals, one of which was under and supported the cylinder. Whether of the Corliss, box, or other type, all for horizontal engines were plain, usually with rounded corners and without paneling or molding. The columns of some of the vertical steam-engines were fluted and ornamented. In one or two cases one large column carried the beam and the

Framing.

entablature extending over the cylinder, to sustain the usual parallel motions. In most of the vertical and beam engines exhibited four or more columns are used to carry the gudgeon-bearings and light framing.

Crank shafts and journals.

Crank shafts and journals.

Wrought-iron shafts, with cranks keyed on, were used for single-cylinder engines, one journal on the bed-plate, the other or outer bearing in a separate pillow-block. In twin and in double cylinder engines, when attachments are to be made outside of the connecting-shaft, bent cranks were used in the smaller sizes, and in some of the larger class cranks were keyed to the shafts, and the crank-pin was fixed in one crank and free in the other; but the majority of such engines had solid double-throw crank-shafts of the marine type, which is decidedly the best practice.

In many cases, even among the best engines at the Exposition, the journals of crank-shafts were too small in diameter and length; several required extra attention and care to keep them cool and prevent cutting.

Bearings.

Bearings.

In most of the engines, perhaps in all having modern beds, the pillow-block was cast to the frame. A few had Babbit or soft metal run in cast iron, but by far the greatest number used brass or gun-metal bearings. These were adjustable to take up wear in various ways. Most of them were

Modes of adjustment.

divided in two horizontal planes, the side brasses set up by wedges on each side, operated by screws or by set screws, the caps generally bolted dead, and having lips or flanges well fitted over the outside of the columns of the pillow-blocks. In some cases the wedges were only placed on the side farthest from the cylinder, so that the wear of the connecting-rod and bearing-brasses could be taken up in opposite directions. There were instances of a division of the bearing into two equal parts, in a vertical plane in some and a horizontal plane in others. Here there is adjustment in but one direction. The practice first above noted is

clearly the best. Outer bearings generally had only vertical adjustments, that is, the brasses were divided in a horizontal plane through the center of the shaft, which is quite sufficient. Caps were held down by four bolts in all the engines exhibited, except in the French Corliss and in the small English engines.

Report on parts of engines.

Bearings.

Connecting-rods.

Connecting-rods.

The beam-engines were fitted generally with cast-iron connecting-rods somewhat ornamental in design. For horizontal engines the prevailing style was wrought iron, generally round, occasionally flattened. A few firms made their rods largest in diameter at the crank end. Various plans were shown of inserting the crank-pin and cross-head brasses, but nothing that was new. While a number of the exhibitors used the form of marine-ended connecting-rod—that is, rods in which the adjustment for wear is made by bolts placed directly in the line of pull—by far the greatest number used open-ended jaws, the brass held in place and the wear taken up by a taper key between the brasses and a gib. In some cases the wear was taken up in opposite directions, so as not to alter the length of the rod, and the key was held in place sometimes by double nuts, generally, however, by a set screw through the side of the block.

Guides.

Guides.

Some of the engines exhibited worked the cross heads on narrow double-bar slides, insufficient in bearing surface. A number had cylindrical bearings, that is, bored in the bed, of course in line with the cylinder; and the constraint of the connecting-rod was regarded as sufficient to prevent the piston-rod from turning. Others had V-shaped guides. The best in practice was found among those which used a flat bearing, somewhat in the style of marine engines, wide and large. The cross-heads were arranged with bearing pieces suitable to the form of guide adopted, and the wear taken up by some form of wedge or screws.

Valves.

Valves.

The engines in the Exposition showed a considerable variety in the form of steam-distribution valves. Although many attempts have been made to supersede the common slide-valve, it seems still to retain its hold, and was used in various forms by more than one-half of the builders represented at the Exposition; double-beat valves, Corliss valves, and a few of piston form were used by the remainder. In

Report on parts of engines.

all cases of slide-valve engines, except of very small ones, some arrangement for cut-off, by the use of an additional slide, was adopted; while in but few cases did the plan obtain of dividing the valve in two parts, that is, placing a

Valves.

valve at each end of the cylinder, so as to reduce the port contents, or distance from the under face of the valve to the cylinder, the advantage of which arrangement is apparent and would be considerable.

There were several instances in which an additional valve on the back of the main slide had some form of trigger re-

Expansion.

lease for working expansion, which, controlled by a governor, can close suddenly, while some few others used four separate

Slide-valves.

slides—two for admission and two for exhaust—placed at the ends of the cylinder. Some of the compound engines had a single slide for both cylinders. There were some examples of receiving-valves, double-beat, above the cylinder, with slide-valves for their exhaust placed below the cylinder.

The double-beat valves were of the ordinary form and do not require special description. The almost universal practice in horizontal engines is to place at least the exhaust-valves underneath the cylinder, in order to allow a ready escape for water, the receiving-valves being on top of the cylinder; but there were examples where all four of the valves were below the cylinder or were arranged on its side. In engines having Corliss valves the usual arrangement was maintained of placing the valves above and below the cylinder.

In Mr. Wheelock's engine, elsewhere described, all the valves are below the cylinder. The instances of the use of piston-valves were not such as to merit notice.

Valve-gears.

Valve-gears.

Quite a large variety of valve movements were found, the most attractive ones designed in some way to produce a per-

Automatic variable cut-off.

fectly automatic, variable cut-off, as the load should require. In fact, it seems that among Continental and English manufacturers this point receives more attention than any other feature of their engines.

Many novel methods are in use, but all those using piston or double-beat valves employ some arrangement for tripper-gearing, by the introduction of a detent, or the alteration of the position of a wedge or incline. In some cases the motion is taken from the pitman, but generally from an eccentric on the main shaft or on a lay shaft alongside, the governor controlling the position of the device for determining the point of cut-off.

Several automatic cut-off arrangements are in use with slide-valve engines, but the larger portion of them have some form of extra slide-valve, whose position is determined by right and left screws, the screw-shaft being rotated by the governor. Either this arrangement or something its mechanical equivalent covers all, excepting those where the well-known Rider gear is used and some half-dozen cases where the governor rotated an eccentric which varied the point of closure.

Report on parts of engines.

Cut-off valves.

The Wheelock steam engine.

Steam-engines.

The automatic cut-off engine exhibited by Jerome Wheelock, of Worcester, Mass., attracted, and deservedly received, marked attention. It furnished power to operate the machinery in the department of the United States and in the sections of Sweden and Norway. The simplicity and economy of this engine and its excellent performance secured for it the award of a grand prize, after a thorough and exhaustive examination by the International Jury.

Wheelock steam-engine.

Grand prize.

The peculiarities of this engine are a reduction to the simplest expression of the instantaneous cut-off valve, which forms the chief feature in the modern first-class engine. Side and sectional views of the cylinder are shown. Instead of four ports this engine has but two, one at each end of the cylinder, directly underneath it. There is at each end of the cylinder, close behind the port, one main and one cut-off valve, views of which are shown in Figs. 1 and 2. Each main valve has a cavity for exhaust, is slightly conical in shape, and is carried in hardened-steel bushes on hardened-steel trunnions. These parts are shown detached in Fig. 3.

Description.

Behind the small chest in which each main valve slides is a cut-off valve having double ports to provide for quick admission of steam. These are also conical and carried in the same way that the main valves are. The steel bush is so adjusted that the valves are held back sufficiently to prevent contact between the sliding surfaces, thus transferring the slight wear to the gudgeons and bushes, which would be inconsiderable in very long service. The cut-off valves are released by the action of the governor, and are closed by weights falling in dash-pots.

Mr. Wheelock's arrangement not only reduces the clearance to a minimum, but guards against a trouble found in four-port cylinders, in a waste of steam through the exhaust-port if there be a leakage in the cut-off valve.

Reduction of waste of steam.

Wheelock steam-engine.

The mechanism for moving the valves is exceedingly simple and effective, easily gotten at, and not liable to excessive wear.

Packing.

The packing-rings are a novelty, being self-adjusting segmental lap-joint rings, making an effective and tight piston. This was demonstrated on several occasions by removing the cylinder-head and operating the engine with the cylinder open.

The Wheelock engine exhibits careful study of detail, judicious proportion, and sound execution.

Dimensions.

The dimensions of the engine exhibited were as follows: Diameter of cylinder, 17 in.; length of stroke, 48 in.; diameter of fly-wheel, 14 ft.; width of face, 25 in.; average steam pressure, 60 lbs.; revolutions per minute, 62; estimated horse-power, 125.

WHEELOCKS' ENGINE.

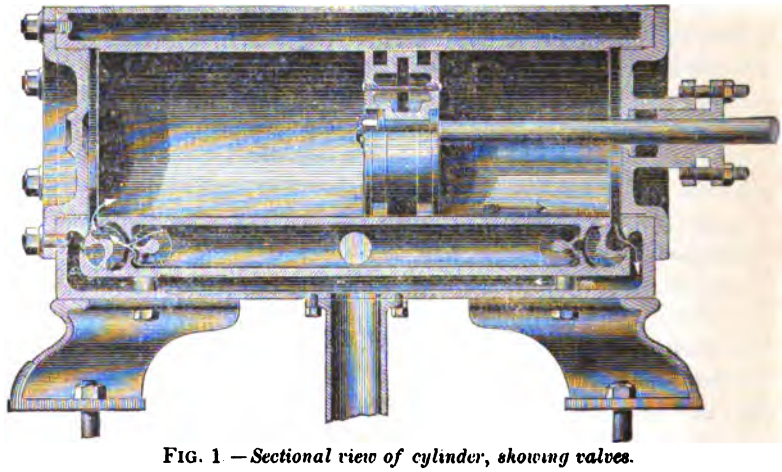


FIG. 1.—*Sectional view of cylinder, showing valves.*

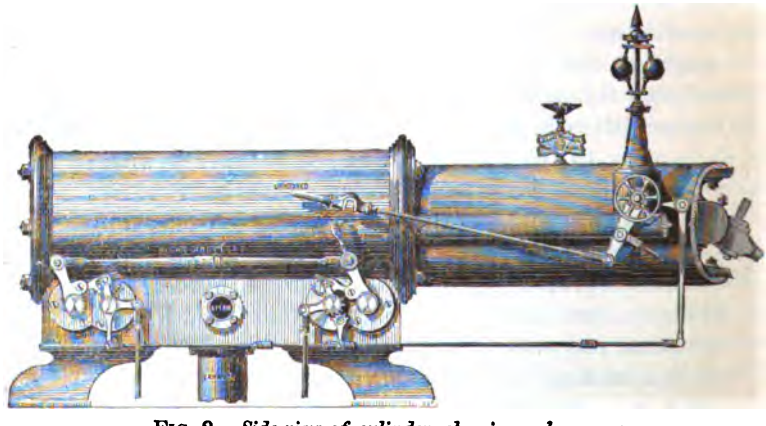
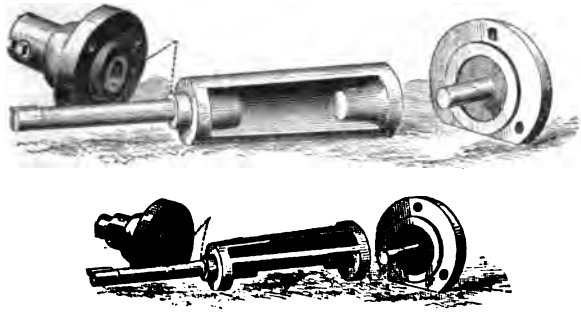


FIG. 2.—*Side view of cylinder, showing valve-gears.*

Wheelock steam-engine.



Valves.

FIG. 3.—*Valves of Wheelock engine. (Detached.)*

Powell's steam-engine.

Powell steam-engine.

Messrs. T. & T. Powell, of Rouen, exhibited a Woolf engine (Plate I), having a variable cut-off controlled by the governor. Vertical compound engines had been exhibited by this firm previously to the year 1878, but only with the ordinary lap-valve cut-off.

Woolf type.

The use of a variable cut-off is of recent date with them, and is on the Correy system, and the following is a description of the mechanism employed: The ordinary arrangement of valve-chests for Woolf engines is retained; the steam comes direct from the boiler into the jacket surrounding the two cylinders, and thence to the valve-chest of the small cylinder. The small valve *a*, which is moved by a triangular eccentric, presents two parallel flat faces, of which the inner face, which slides on the valve-face of the small cylinder, is formed like an ordinary valve. Two rectangular ports open into the outer face, the dimensions of which correspond to the sectional area of steam-port uncovered by the inner face. Two expansion-slides, *b b*, work on the back of the valve, and are fixed in two rods, *c c*, each of which passes through a stuffing-box.

Variable cut-off.

Description.

The diameter of the slide-rods is calculated so that the pressure of the steam on the upper extremity of each rod, plus the weight of the rod, may be greater than the frictional resistance of the slides and of the packing in the stuffing-boxes; by this means the slide-rods, with the slides, fall as soon as they are set at liberty, and the employment of springs or counter-weights for enforcing their descent is rendered unnecessary. Each slide-rod is formed with a small piston below the stuffing-box, which plays in an air-cylinder, *e e*, and when the rod falls suddenly the air is compressed under the pistons, and shocks are obviated. The valve-rods *c c* are moved by two eccentrics, *f f*, connected to two cylindrical rods, *g g*, which work in guides

Mode of action.

Powell steam-engine.

fixed upon the column and move within two wrought-iron pieces, *h h*, which carry the trigger, and are cottered to the lower ends of the slide rods. The upper end of each of the rods *g g* is for a short length reduced in the lathe, being chucked eccentrically, so as to form a crescent-shaped shoulder, *j*, at one side of the rod. (See Figs. 5 and 7 in plate.)

Description.

This part is of hardened steel. The other piece, *i*, of hardened steel engages in the square opening of the pieces *h h*, and can be displaced horizontally by an amount equal to the shouldering on the rods *g g* on being acted upon by the crank and articulated lever *k* (Fig. 5). The piece *i* is traversed by the upper end of the rod *g*, and the opening through it is of a circular form, so that it applies exactly to a semi-circumference of the rod, with which it is maintained in contact by a spring, *l*. When one of the eccentrics is at the bottom of its stroke the slide-rod in connection with it rests on an india-rubber washer at the bottom of the air-cylinder. The port is closed by the slide, and the shoulder *j* of the rod *g* has then fallen about one-eighth of an inch, so as to permit the piece *i* to settle itself properly upon the shoulder of the rod, being pushed thereto by the spring (as shown in Fig. 5, Plate I).

When the movement is commenced, the eccentric pushes the shoulder of the rod against the piece *i*, the slide is raised, the port is uncovered, and the crank-lever *k* is raised; at the same time it carries a steel piece terminated by a knife-edge, *m*. At any given point of the stroke the knife-edge *m* may be brought into contact with one of the cast-iron cams *n* (Fig. 2), and the eccentric continuing its movement, the lower end of the lever *k* will describe on its pivot a small arc of a circle and will push the piece *i* off the shoulder of the rod against the action of the spring. The slide and its rod are thus set free, and by the pressure of the steam it is suddenly pushed downward and the port is closed. The position of the cam *n* is determined by the action of the governor, and the knife-edge *m* comes in contact with the cam *n* earlier or later to free the expansion-slide.

Collmann's steam-engine.

Collmann's variable exhaust steam-engine.

An engine exhibited by A. Collmann, of Vienna, Austria, showed an ingenious arrangement of valve-gear, differing from the usual system of catches and pawls adopted by the imitators of Corliss. The valves for the admission of steam are caused to operate by means of the combination of two

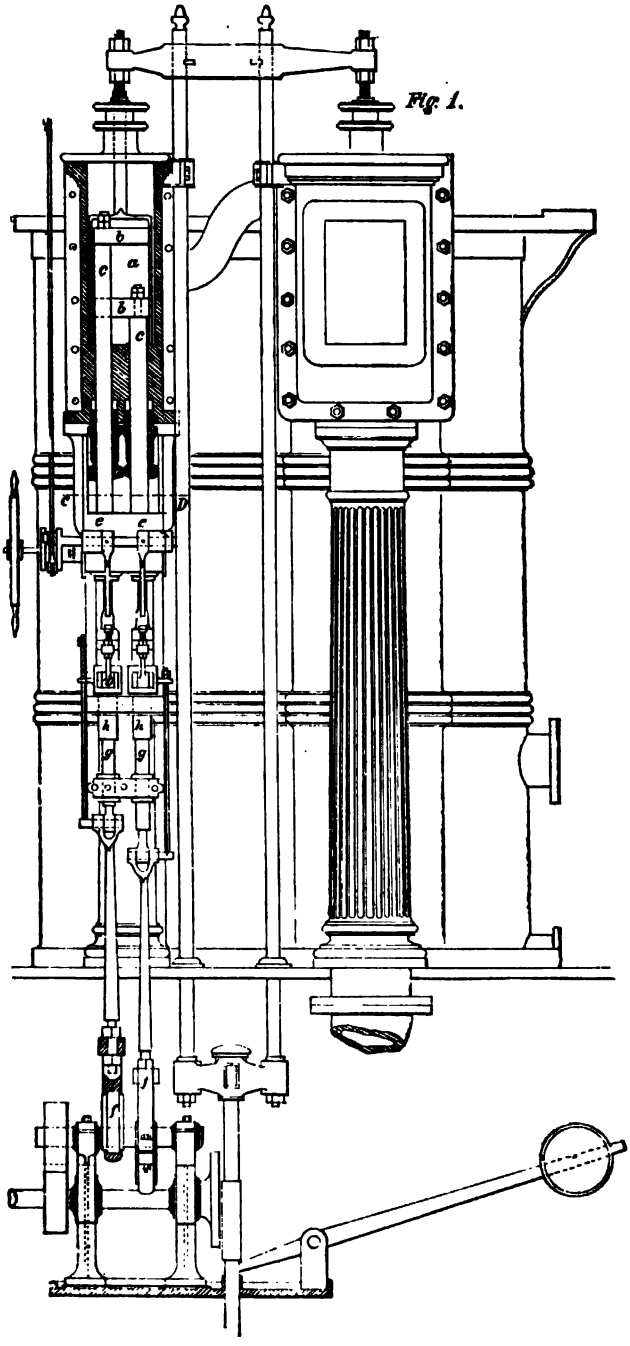


Fig. 1.

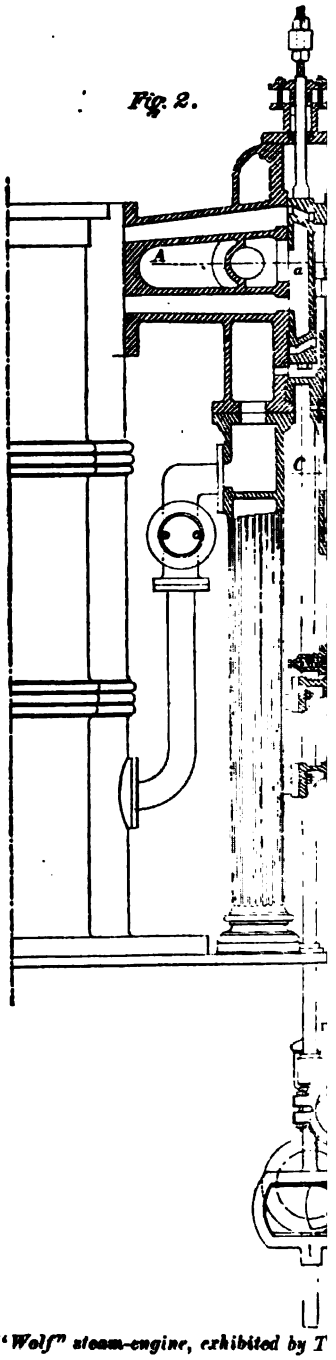


Fig. 2.

"Wolf" steam-engine, exhibited by T

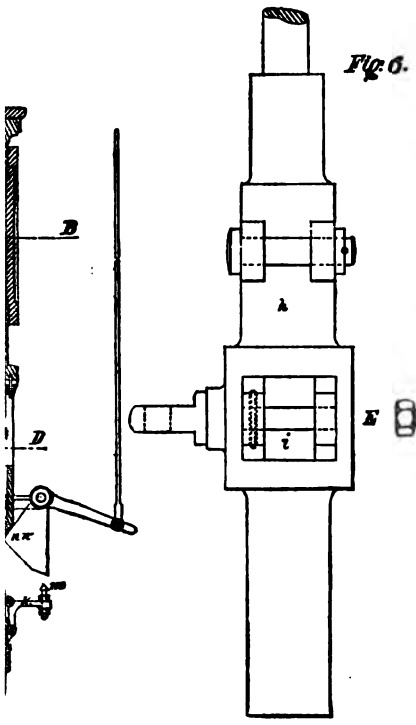


Fig. 6.

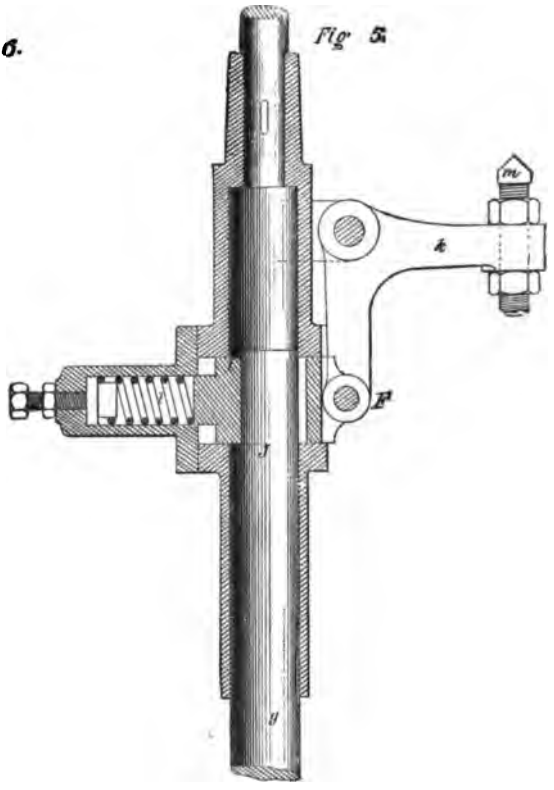


Fig. 3. Section on line A B.

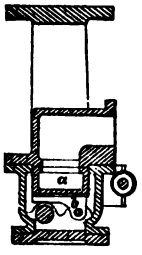
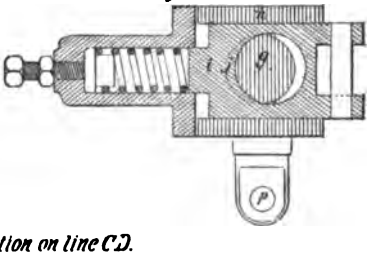


Fig. 7. Section on line E F.



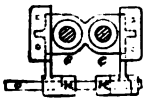


Fig. 4. Section on line C D.

T. Powell, of Rouen, France.

[Plate 1, opposite page 371, vol. IV.]

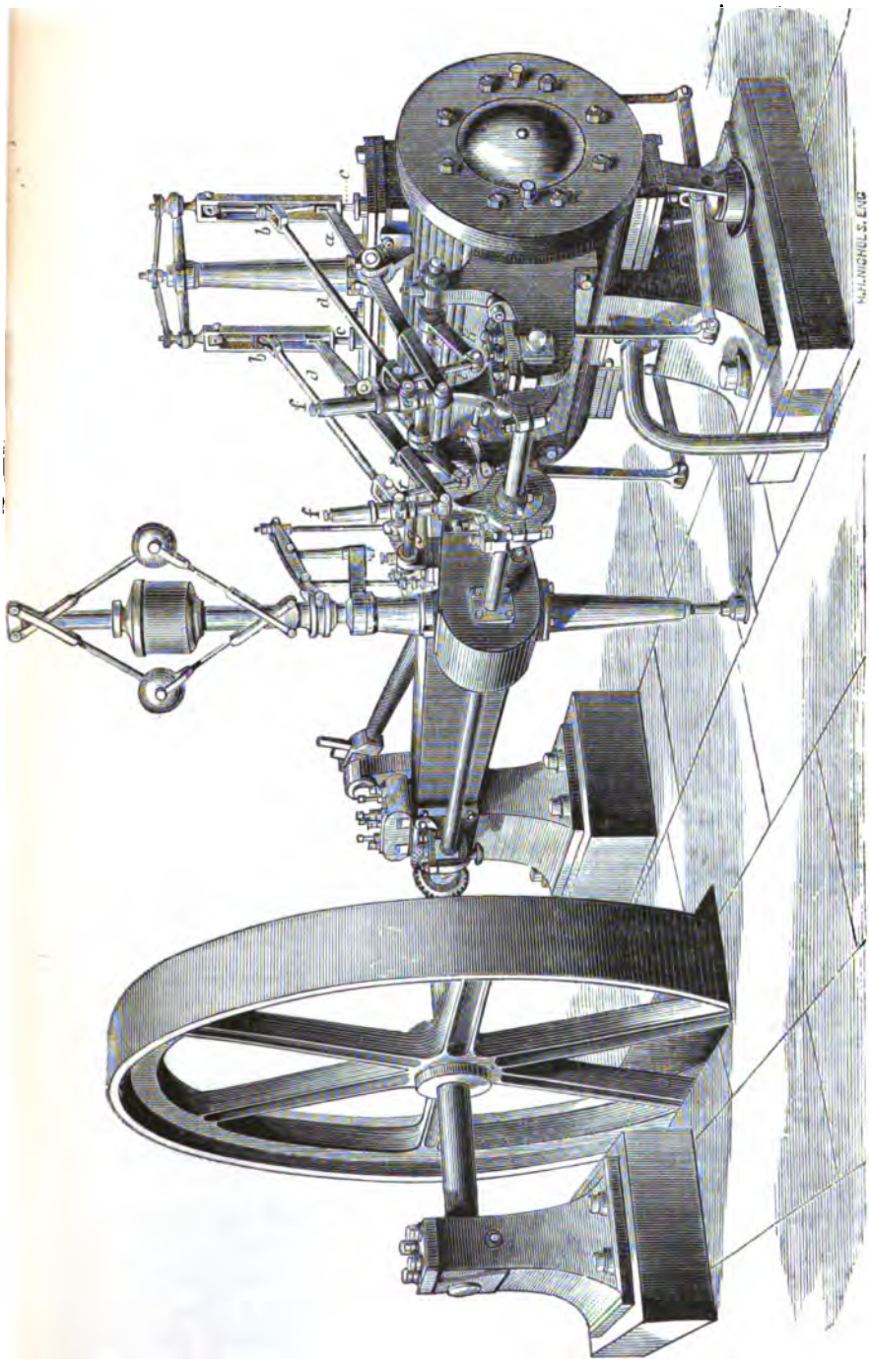


FIG. 4.—*Collmann's variable exhaust steam-engine. (Perspective view.)*

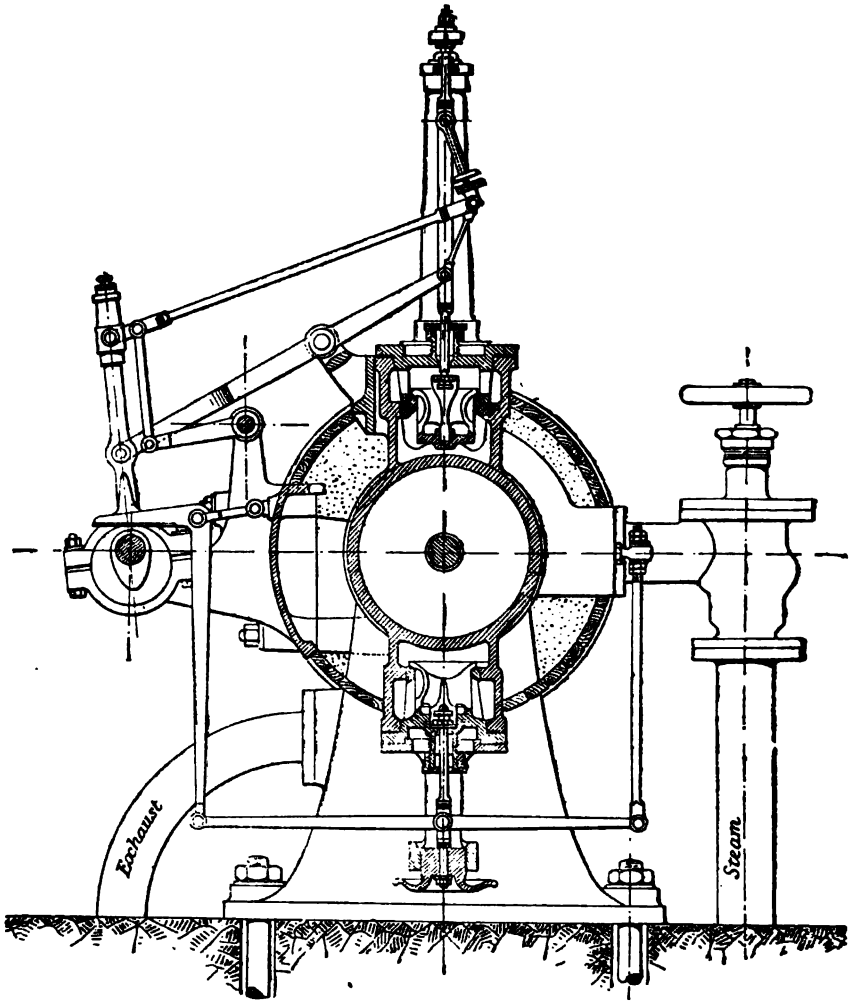


FIG. 5.—*Collmann's variable exhaust steam-engine. (Transverse section)*

Collmann's steam-engine.

motions, one of which, taken from the main shaft through miter-wheels, is constant, while the other, taken from a governor, is variable. Referring to the cut, Fig. 4, a constant motion is communicated through a lever, *a*, to the lower end of a toggle, *b*, the other end of which attaches to and operates the valve-stem *c*.

Description.

The variable motion from the governor controls the duration of admission of steam into the cylinder, being communicated to the toggle by a rod, *d*, one end of which attaches to the toggle and the other to a slide, *e*, carried on an arm, *f*, worked by the positive motion, the position of which slide on the arm is regulated by the action of the

governor, through the rod *g*, the arm *h*, and the rod *i*, and the resultant motion gives a determined movement, which raises and lowers the steam-valve for all degrees of cut-off. The valve is never allowed to drop, but is quickly raised and quickly lowered. The exhaust-valve may be operated in any convenient manner. Collmann's steam-engine.

Winterthur (Swiss) condensing steam-engine.

Winterthur condensing steam-engine.

A horizontal condensing engine (Plate 2) exhibited by the Swiss Locomotive and Engine Works of Winterthur presented an appearance of excellent workmanship, which entitled it to rank among the best exhibits of steam-engines.

Description.

The framing or bed-plate is Y-shaped, the cylinder being attached to the single arm, the others each carrying a shaft-bearing, the whole resting on two pedestals, one under the cylinder, the other transversely under the shaft-bearings. The cross-head bearings are large and cylindrical, being bored out true with the cylinder. The piston-rod is prolonged through the cylinder-head, the end carried on a flat slide, and also connecting to a double bell-crank lever, which drives the air-pumps, which, with the condenser, are placed below the top of the foundation on which the bed-plate pedestals rest. The crank is formed of two cast-iron disks, with counter-weights, connected together by a heavy wrist-pin. The peculiar feature of this engine is its receiving-valve gear, the movement for which is obtained from a pin, *a*, fixed to the connecting-rod near its center, and causing the lower end of a vertical lever, *b*, to travel in an oval curve; the upper end of the vertical rod attaches to a parallel motion, the stationary points of which are carried by a plate, *c*, susceptible of partial rotation by the governor. When the governor is at its lowest point the plate and the stationary point of the parallel-motion levers lie in an oblique plane to the oscillation of the vertical lever, and consequently a point below the fulcrum of said vertical lever travels longitudinally a desired distance, due to the angle of the plate. As the governor-balls rise, the plate is rotated to a horizontal plane; the fulcrum of the vertical rod receives a nearly vertical motion only, as does also the point below the fulcrum. To this point is attached a horizontal rod communicating its motion to the valve-lifters, so that when the plate is in its horizontal position the lift of the valves is slight, and consequent an early closure obtains; but with the plate in its oblique position a larger lateral movement

Valve-gear.

Automatic variable cut-off.

Winterthur condensing steam-engine.

is given to the horizontal rod, an increased lift of valve, and consequently later closure. The valves are double-beat flat-surface bearings, held down by springs which compel the valve to maintain equal descent with the lifter, and so prevent shock in seating. The exhaust-valves are similar; placed beneath the cylinder, and operated by an ordinary eccentric on the shaft. The cylinder is steam-jacketed, and the work throughout is well and neatly done.

Beer's winding engine.

Beer's winding engine.

In the Belgian section was exhibited a winding engine, by M. Beer, a well-finished piece of machinery and specially adapted to the purpose for which it was designed. It consisted of two cylinders, 21″ in diameter, 48″ stroke, resting on separate box-section bed-plates, extending under the plummer-block and coupled at right angles to one shaft; on the center of the shaft is a brake-wheel, on each side of which is a rope-drum. In this engine expansion is used in a moderate degree, controlled by a governor, and yet the engine is at all times easily handled.

Essential conditions of a winding engine.

The following extracts contain four propositions which M. Beer holds to be essential and necessary in a winding engine:

"(1.) The valve gear must be such that, in ordinary work, the engine shall run properly with that ratio of expansion which is most convenient, no matter what the pressure of steam and the variation in resistance.

"(2.) The cut-off must be suppressed automatically whenever it is necessary to handle the engine, no matter what may be the cages in the pits; that is to say, if the cages have to be moved through moderate distances up or down when in the pit, the cut-off valve must at such times throw itself out of action.

"(3.) The engine must work without expansion when men are being raised or lowered in the pit.

"(4.) The cut-off valve, which only operates when the engine is working regularly in winding coal, must be simple and efficient."

Expansion apparatus operated by governor.

These objects are secured in this engine by the use of a heavy and powerful governor, operating a pair of expansion-slides on the back of the main valve, which are caused to approach to or recede from each other by a spindle having a right and left thread, and operated through rack and pinion gear directly by the governor.

Mode of working.

In hoisting a load, until the engine attains nearly its maximum speed, the cut-off valves are not brought into play; but when the determined speed is reached, the governor takes the control, and, by revolving the spindle, establishes the desired cut-off action, which is so maintained during the remainder of the lift by proportioning the admission of steam to the load, keeping the ascent of the cage at a fixed velocity.

TION.

PLATE 2.

COMMISSIONER SWEENEY'S REPORT.

Steam and Gas Engines.

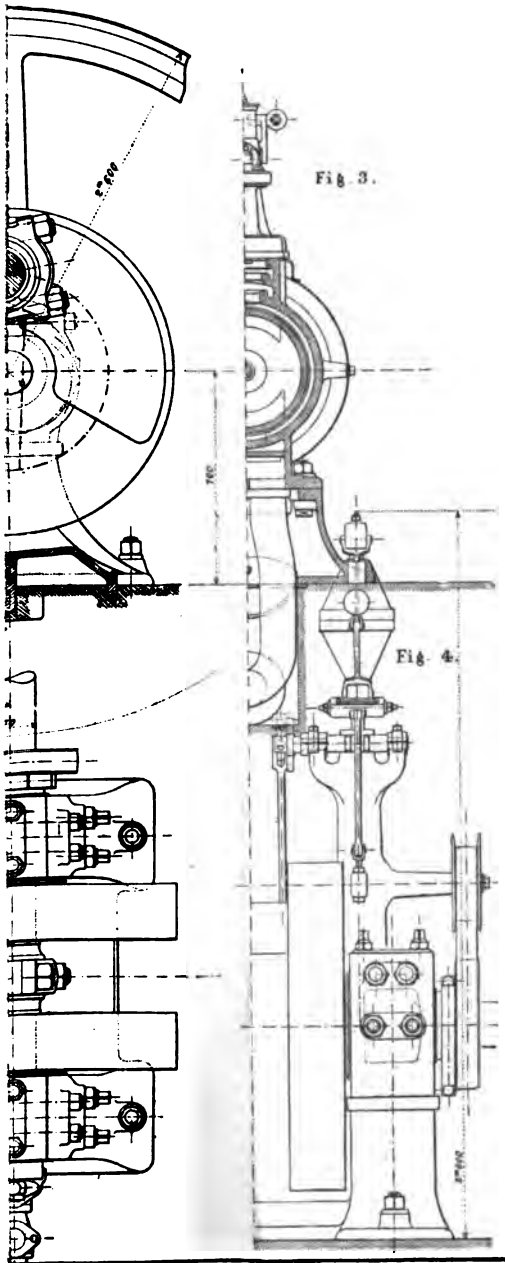


Fig. 3.

Fig. 4.

The depth of pit for which this engine is designed is 1,638 ft.; the time of ascent, 60 seconds; number of revolutions of engine 48.7 per minute. A flat cable is used, winding upon itself between disks; the radius of the smallest coil is 32″.3, and of the largest 97″, making a compensation for the weight of the cable. In hoisting men, necessarily at a low rate of speed, the governor and expansion gear do not come into play, the entire control being in the hands of the operator. The engine is fitted with a stationary link-motion for reversing, which is done by steam in an auxiliary cylinder. A small steam-cylinder is also used for applying the brakes to the brake-wheel, the brake-blocks being carried on wrought-iron inclined levers, coupled together by long links. The working pressure of steam used is 60 lbs. to the square inch.

Beer's winding engine.

Description of its operation.

Sulzer Bros'. compound condensing steam-engine.

Sulzer Bros'. condensing steam-engine.

The compound condensing engine of Sulzer Bros., Winterthur, Switzerland, attracted much attention. Its cylinders are 11″.81 and 22″.71 in diameter, respectively, and 35″.43 stroke, the framing of the Corliss type.

Description.

The cylinders are placed one behind the other, each resting on its own foot-bracket and connected together by a distance-piece.

The piston-rod extends through and runs in a guide beyond the large cylinder, driving by a link a pair of pump-levers which work an air and feed pump, the former double-acting. The condenser is a horizontal cylindrical vessel.

Valves.

The valves are double-beat, fitted with springs and dash-pots, the receiving placed above and the exhaust below the cylinders.

Valve-gear

The novel feature of this engine is its valve-gear. A long shaft parallel to the axis of the cylinder, driven by miter-wheels from the main shaft, drives the governor and carries four eccentrics for operating the valves of both cylinders, each eccentric moving one exhaust and one receiving valve. The exhaust-valve is worked (see accompanying cut, Fig. 6) by a rod, driven by a pin in the eccentric-rod, which is itself supported by a gudgeon in a rocking arm. As the eccentric revolves the end of its rod will describe a peculiar closed curve, while the gudgeon will move in an arc; but the gudgeon is prolonged at the other side of the eccentric-rod and carries a rod the upper end of which is jointed to an arm under which is the lever which lifts the steam-valve. As

Governor cut-off.

Sulzer Bros'. condensing steam-engine.

the eccentric revolves the lower end of the rising rod moves in an arc, while the upper end rises and falls also in an arc. Communication is effected between the arms by a detent, which is a bell-crank hung loosely on a pin in the arm where the rising rod is attached. The rod to the left hand is controlled by the governor through a system of bell-cranks.

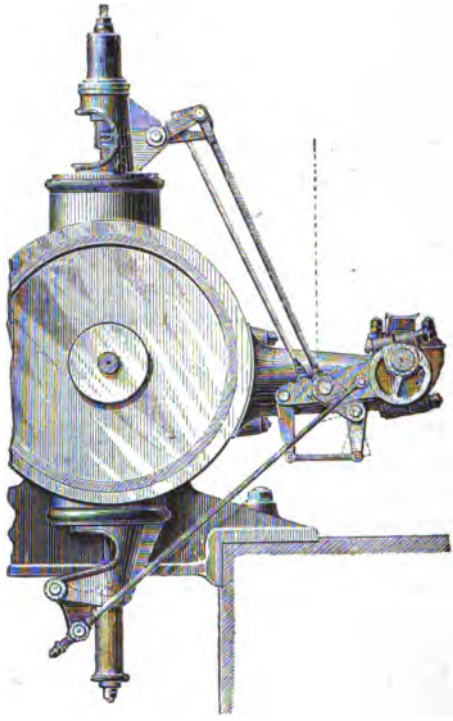


FIG. 6.—*Sulzer Bros'. compound condensing steam-engine.*

Hermann Lachapelle's condensing steam-engine.

Hermann-Lachapelle's horizontal compound condensing steam-engine.

J. Hermann-Lachapelle, of Paris, France, exhibited a horizontal compound condensing engine (Fig. 7).

Description.

As in the beam-engine of the Woolf system, the two cylinders are put together under one cover to prepare for the circulation of steam, and the two pistons work together in the same way. A single slide-valve in a chest placed below the

Valves.

cylinders governs the distribution of steam for both cylinders, and the water condensed in the cylinder is thus allowed to flow away with the escape of steam, and so avoid jars frequently occurring from the presence of water in the cylinders; and but one eccentric, one eccentric-rod, and one

valve-rod are required. The slide-valve is balanced and a cut-off varies the admission of steam into the small cylinder from a minimum to eight-tenths of its stroke, while in the large cylinder steam is uniformly allowed for eight-tenths of its stroke. The two piston-rods are attached to one cross-head carried on slides, and a forked connecting-rod transmits the sum of the effect of both pistons to the crank.

Hermann-Lachapelle's condensing steam-engine.

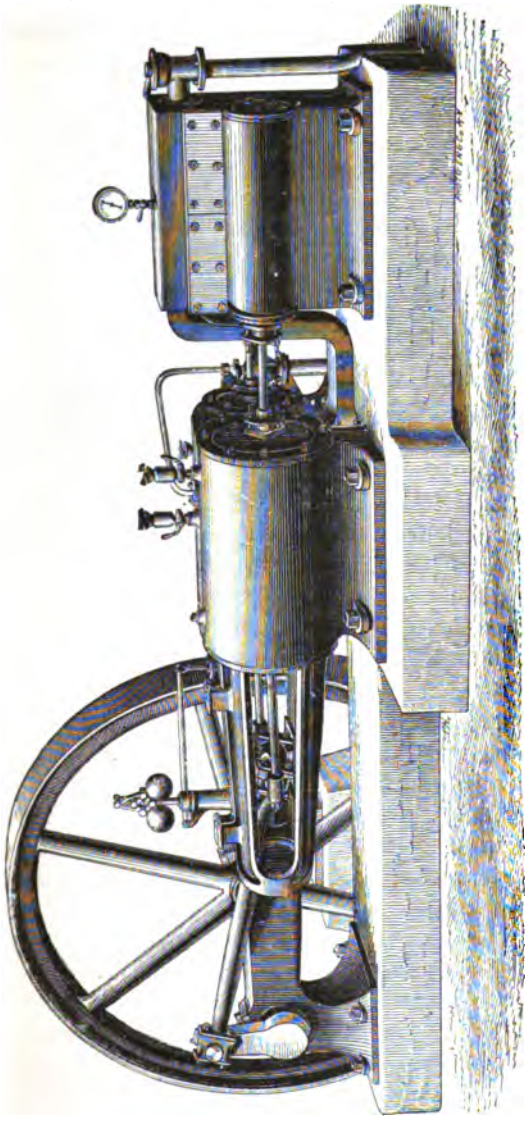


FIG. 7.—*J. Hermann-Lachapelle's horizontal compound condensing steam-engine.*

The shaft is larger than ordinary rules require, and turns in large pillow-blocks lined with bronze.

Hermann-Lachapelle's condensing steam-engine.

A simple and efficient governor is employed. The air and feed pumps are in the same line as the cylinders at the other end from the shaft, and their plungers are on the prolongation of the two steam piston-rods, an arrangement avoiding the necessity for a beam, crank, or other device to transmit movement to the pumps. A box bed-frame of Corliss design gives good finish and appearance to these engines.

Brotherhood steam-engine.

Brotherhood engine.

A new form of Brotherhood engine was exhibited by Messrs. Flaud & Cohendet, of Paris—a vertical compound engine with two single-acting cylinders, one, the high pressure, being surrounded by an annular low-pressure cylinder. The steam distribution is effected by one oscillating cylindrical valve worked by a single eccentric on the shaft, the steam working only upon the top sides of the piston.

Flaud & Cohendet.

Compound engine.

The degree of expansion obtained is due to the amount of lap in the valve.

Mode of working.

The large cylinder working full stroke, the steam is exhausted directly from the small cylinder under the valve into the large cylinder. The cranks are opposite each other in the same plane and lie directly under the cylinders. The shaft passes through the base and is surrounded by the exhaust steam working through stuffing-boxes and glands at each outer end.

The inner side of the annular piston-head is made somewhat longer than the desired stroke, and a spring-ring is placed in a groove cut in the cylinder. The ring remains stationary, and the head travels over it, thus allowing the spring of the ring to be outward, in place of the reverse, which would occur were it placed in the piston-head. The connecting-rods are used only in compression, and have their oscillating bearing in the piston-head itself.

This engine is also used with a condenser.

Brotherhood steam-engine. Flaud & Cohendet.

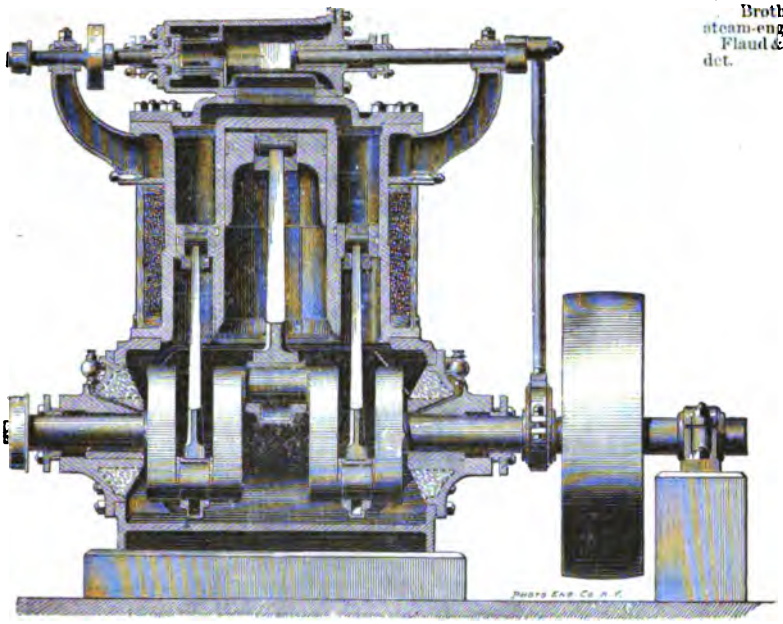


FIG. 8.—*Flaud & Cohendet's "brotherhood" vertical compound steam-engine. (Vertical longitudinal section.)*

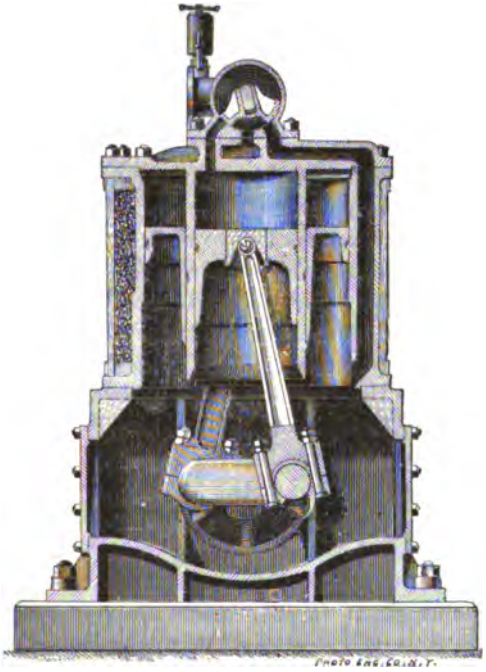


FIG. 9.—*Flaud & Cohendet's "brotherhood" vertical compound steam-engine. (Vertical transverse section.)*

Bernay's twin-cylinder engine.

Bernays's twin-cylinder engine.

In the English department Mr. Joseph Bernays, of London, exhibited a twin-cylinder engine (Fig. 10), in which the crank is rotated by the intervention of a triangular connecting-rod, an arrangement not new and long since apparently abandoned, but which this exhibitor makes practicable by an ingenious arrangement of eccentric and valve gear.

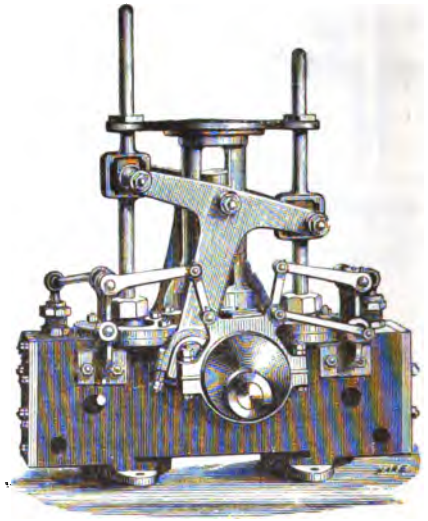


FIG. 10.—*Bernays's twin-cylinder steam-engine.*

Description.

The two upright double-acting cylinders are placed with sufficient space between them to receive the crank-shaft. The pistons are connected to one crank by means of a triangular connecting-rod, which causes them to move as if connected to two cranks at right angles to each other.

Steam distribution.

The steam distribution in the two cylinders is governed by one ordinary eccentric and its connections in a manner analagous to that by which the main crank governs the motion of the two pistons.

Valve-gear.

Two eyes are provided on the eccentric-ring, carrying rods or levers, through which the valves are acted upon. The position of, and distance between, these eyes bear the same relation to the throw of the eccentric as the measurements of the main connecting-rod bear to the throw of the crank, reproducing on a smaller scale the triangular connection between the crank and the two piston-rods in the eccentric and valve-rods, and the steam is correctly distributed. The eccentric is loose in the shaft and is thrown to the right or left for the purpose of reversing the engine. The position

of the crank-shaft in relation to the cylinders may be varied in height to suit any required purpose. Bernay's twin-cylinder engine.

In this engine there is no dead point, for the reason that both pistons can never be at the ends of their respective strokes at the same time, since they reach their limit of movement when the crank-pin passes a point in line closest to the pin of the triangle to which either engine-piston attaches.

Ransome's tree-felling engine.

Ransomes' tree-felling engine.

Ransomes, of Ipswich, England, showed an application of steam-power to felling trees (Fig. 11).

A small steam-cylinder, with comparatively long stroke, mounted on a light wrought-iron frame, is pivoted on its center; a movement around this pivot is controlled by a worm-wheel and screw-gearing into a circular rack. A saw is rigidly fixed to the cross-head, the teeth of the saw arranged to cut only during its in-stroke, that is, the teeth are hooked on one side and have a long bevel on the opposite one; the saw makes a draw cut during its passage toward the cylinder, which enables a brace between the cylinder-frame and the tree to resist in compression alone the force of the cut. The steam distribution is effected directly from the cross-head, and so arranged as to take full steam for the in or cutting stroke of the saw, and but one-tenth the amount for the return or idle stroke.

Description.

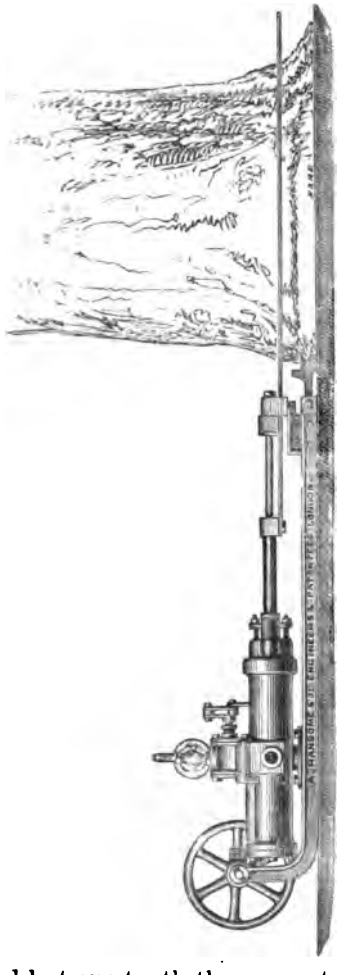


FIG. 11.—*Ransomes' tree-felling engine.*

Ransome's tree-felling engine.

Any convenient form of boiler may be used, and connection made between the engine and boiler through a long flexible steam-pipe, which allows great range in position of the engine relatively to the boiler, while the boiler maintains any given position.

The engine and frame are very light and easily transported by two men from place to place.

Hathorn, Davis & Davey. Appleby Bros. J. Fowler & Co. J. & H. McLaren.

Hathorn, Davis, & Davey, of Leeds, manufactuers of differential compound pumping engines, Appleby Bros., of London, makers of hoisting engines and machines, and John Fowler & Co., of London, and John & Henry McLaren, of Hunslet, both firms builders of traction engines and machinery, exhibited valuable machinery but no special improvements on previous products such as come within the scope of this report, nothing having been shown that has not already been noticed in reports made to the government concerning former international exhibitions.

Gas-engines.

GAS ENGINES.

Some half dozen gas-engines were exhibited, and the most notable features of novelty were found in the "Otto silent gas-engine." In it, by an entirely new idea, the proportionate amount of air is increased for volume of gas used, and a consequently less sudden and abrupt explosion is secured. As it has generally been found that the most serious objection to such engines is a too sudden explosion, any method of correcting it is certainly worthy of notice.

Otto gas-engine.

Description.

The Otto engine is horizontal, and resembles greatly an ordinary horizontal steam-engine, but the cylinder is entirely open at the front end, while across the other end moves a slide-valve regulating the admission of air and gas.

Mode of working.

This valve is driven by a small crank connection off the end of a shaft lying alongside of the bed-plate of the engine and at right angles to the main shaft. This "lay" shaft receives its revolution from the main engine-shaft through a pair of bevel-gears of ratio 2 : 1, the main shaft making two revolutions to one of the lay shaft. When the piston is ready to start from the back end of its stroke, the slide-valve is in position admitting air and gas, the air in much larger proportion than ordinarily employed (that is, the gas largely diluted); this admission continues for a portion of the piston passage, when it is discontinued by the action of the slide-valve. The acquired momentum of the fly-wheel and moving parts carries the piston over its dead point, and

causes it to return to the back end of its stroke, so compressing the air and gas first admitted into about one-third the space originally occupied at the time of its admission; at this point the continued movement of the valve admits the spark and the explosion of the admixture occurs, driving the piston to the front end of the cylinder; the fly-wheel momentum returns the piston to the back end, expelling the burnt gases through a separate exhaust-valve, also driven from the lay shaft; and the piston, having again reached the back end, receives another charge of the combustible. From this it will be understood that the explosion occurs only for every fourth stroke of the piston. The motion for the other three strokes is caused entirely by the stored-up momentum. A governor is, however, attached and the engine gives very regular speed. The consumption of ordinary coal gas is reported to be 20 cubic feet per horse-power per hour.

Otto gas-engine.

Mode of working.

The Bisschof vertical gas-engine is constituted to fill a Continental demand for light powers, driving lathes in houses, and other small requirements. So low a power is made as one man-power, equal to about $\frac{1}{12}$ of a horse-power. In this engine the explosion occurs in the latter half of the cylinder. The earlier movement of the piston draws in the air and gas, regulated by an eccentric on the shaft; it is then exploded by a jet kept constantly burning, and propels the head to the extremity of its upward stroke. During the downward passage of the piston the exhaust is made, and the explosion again repeated on the upstroke. No water is used to cool the cylinder, which is entirely done by radiating ribs cast to the cylinder, and said to answer all requirements. The crank-shaft is placed on one side of the center line, so that, when the force of the explosion occurs, the angularity of the connecting-rod is very slight, but consequently excessive during the downward passage of the cross-head.

Bisschof gas-engine.

Mode of working.

APPARATUS FOR THE INSTANTANEOUS GENERATION OF STEAM.

Instantaneous steam apparatus.

In these apparatus liquid fuel (petroleum, naphtha, etc.), in the raw state, is changed into motive force, with a special application to produce high temperatures.

Dusaulx's steam apparatus, shown in Plate 3, works by an instantaneous production of steam in motor cylinders. This vaporization is obtained by the combustion of mineral

Dusaulx's apparatus.

Dumulx's instantaneous steam apparatus.

oils, injected in the liquid state under the pistons, when these last have gone through about two-fifths of their ascending course, drawing by suction a certain quantity of air which comes to saturate this first fraction of the capacity of the cylinders. At the moment of the injection of these oils in a certain state of division, a spark proceeding from a Ruhmkorff coil inflames the mixture in the interior, at the same time that a quantity of water fixed and covering the piston, which is in the open air, is thus injected in a like state of division into the midst of the inflamed gases. The distribution of this water is effected in a constant manner, regulated by a tap at the surface of the moving pistons, which form basins to receive it; it traverses previously a circuit in contact with the gases of escapement, so as to raise its temperature as nearly as possible to 100°. The little apparatus of injection, screwed on the piston which it traverses, is fed at each stroke with a fixed quantity of this water, in order to throw it into the fire-grate at the opportune time.

Mode of working.

Injection of liquid fuel, air, and water.

Pressure developed.

The mean pressure developed under the influence of this double phenomenon is from eight to ten kilograms per square centimeter. It acts then upon the internal surface of the piston, which it pushes with energy, while slacking itself.

Exhaust.

This mixture of steam and gas escapes afterward into the atmosphere when the piston arrives at the end of its course.

Quantity of fuel employed.

The quantity of raw mineral oil thus employed is from one to one-half liters per hour to produce one horse-power; the volume of water evaporated in the same time is from ten to fourteen liters. The same apparatus, while performing the function of a ventilator or blowing cylinder, can be advantageously utilized to produce high temperatures; it suffices to modify the distribution of oil, which is injected in excess under the pistons, by diminishing so much the quantity of water; the weak portion of the injected oils, which is inflamed, produces the gaseous state of the whole, with a temperature of 180° to 200° in the escapement. This escapement, instead of being made into the atmosphere as above, traverses a powerful pipe, which pours it into a reverberatory furnace or muffle, into which its combustion is effected.

Water evaporated.

Subsequent use of heated escape gases.

The air sent by the ventilator, set in motion by the apparatus, goes along in a bundle of capillary tubes, of a certain length, in contact with these escapement gases, without mingling with them; the mixture takes place at the orifice of the issue of the pipe. This arrangement has the effect of bringing the air to the same temperature as the gases before mixing it with them. In the exhibited apparatus the

mingled with heated air from the ventilator.

mixture is thus evacuated from 150 to 180 cubic meters by the hour, with an expenditure of three to four liters of petroleum passing through the cylinders, and two to three liters of heavy oil of gas tar distributed along the pipe and carried along by the evacuated gases. This complete combustion leaves no residue, and produces an excessively high temperature, with a light pressure, allowing it to be managed in the whole circuit without escape-chimney. Dusaulx's instantaneous steam apparatus.

ANDREW J. SWEENEY,
Additional Commissioner.

MACHINES AND MACHINE TOOLS.

WILLIAM T. PORTER.

389-390

REPORT

ON

MACHINES, APPARATUS, AND MACHINE TOOLS.

Paucity of new machines at the Exposition.

The Exposition at Paris—following so closely upon those of 1873 at Vienna and of 1876 at Philadelphia—left little time for improvement or even changes of form; and one looked almost in vain through the vast display of machinery to find anything which had not already been fully reported upon by commissioners at a previous exhibition or shown in Philadelphia in 1876.

The American exhibit.

The American show of machinery was limited when compared with those of France and Great Britain, the two great exhibitors, but it attracted as much attention as any other machinery section, and certainly contained as much that was new. The short interval since the Centennial Exhibition, the distance of that in Paris, and the very brief time for preparation of exhibits to the latter, all tended to make our Exhibition limited as to quantity, though its quality was admittedly excellent.

Its quality and attractiveness.

Excellence of British workmanship.

In point of workmanship the British exhibitors were in advance of all others, judging altogether from outside appearances, as no opportunity was offered to make any other examination. All their details seemed to be carefully worked out, and one could see all around him, in their section, what it was difficult to find anywhere else—that the makers of the machinery were thoroughly well acquainted with the uses of the fundamental tool of the machine-shop of to-day—the planing machine. In their work we almost invariably found that clean-cut, sharp, and flat finish which is a sure indication to a workman that the parts have been separately finished, and then brought together, making the grand whole, without being fitted each piece to its neighbors in the process of erection. They undoubtedly made the finest show of machinery in the Exposition, and, as might be expected, only second in its extent and range of classes. Very nearly the whole of it, however, has been exhibited and reported upon before.

Extensive use of the planing-machine.

Superiority of British exhibit.

Many claims for improvements on different well-known and valuable machines were made; but, upon inspection,

they proved only how slight a change might be made into a matter of great importance by the stretching of an elastic imagination. In the United States section a model was shown of Blake's ore and stone crusher, probably placed there that it might be compared with the so-called improvements on that machine. If this was the purpose, it was a wise one, and might be followed by others with good results in future; for by comparing this model of the original machine with the claimed improvements an impartial man would certainly discover that the only change from the original, which was not really a detrimental one, was the mere substitution of a thin, light, crushing plate for breaking soft stone, in place of using the heavy, strong plate, or rather jaw, capable of crushing the hardest and strongest rocks, which is usually placed in the machine. The Blake machine is so exceedingly simple and so effective, that it seems almost ridiculous to follow that particular direction any further with the hope of making improvements.

Blake's ore-crusher.

As to modifications claimed as improvements.

Paper-working and printing machinery and apparatus.

Paper-working and printing machines.

Kientsy Bros.

Kientsy Bros., of Paris, had on exhibition a very good lot of specimens of their manufacture of paper machinery, among which the only notable thing was an engine-tub made, and beautifully made, of pebbles and hydraulic cement (concrete), in the use of which the French possess wonderful skill.

Engine-tub of cement.

L. L'huillier. Fourdrinier machine.

L. Lhuillier, of Vienne, (*Isère*), showed a Fourdrinier machine in operation, apparently a creditable piece of work, but although a descriptive catalogue was promised, it has never been received. The machine had the appearance of great strength, each part driven by separate cone-pulleys for changing and regulating the speeds. The cutter was novel, but evidently lacked one great requisite—speed. The paper is cut by a straight blade, moved by a cam motion at each end, and raised by counterpoise weights after the passage of the cams and the making of the cut. The paper is fed up at each stroke by a crank motion moving a bar running across the machine, the length of the paper being regulated by the radius of the crank-pins. The machine is almost noiseless, because it is free from shocks, and is certain in the length of its sheets—two great recommendations.

Paper-cutter.

The exhibit of printing machinery was small compared with that at the Centennial Exhibition. The most important exhibitor was the house of Marinoni, of Paris, comprising quite a number of different forms, among which were three continuous presses, for which they claimed special advantages—one for printing newspapers of small size and

Marinoni's continuous printing-machine.

the other two for large-sized papers. They were said to count, print, cut, arrange, and pass off the papers in packages of one hundred. The cutting arrangement is covered by a patent bearing date October, 1877; and for the counting arrangement the claim was made that it was entirely new. Unfortunately, after making very many visits for the purpose, the writer failed to see any of these machines in successful operation, the cause of failure being, in his opinion, due to the impossibility of such paper as they were trying to use being passed through a continuous press, and not to any grave faults in the machines themselves.

Marinoni's printing-machine.

Cutting, folding, and counting.

In the British section an Ingram continuous rotary press was every day in successful operation, printing copies of the London "Illustrated News." The paper from the roll was passed through a pair of cylinders, where it received the imprint of the letter-press forms; it then passed to the picture cylinders, where the illustrations were printed on the other side of the sheet; thence to the cutter; and finally to the folding arrangement, which delivered the finished copies at the rate of about six thousand per hour.

Ingram continuous printing-machine.

"Illustrated London News."

Derriey-Dalloz, of Paris, had on exhibition a continuous rotary job press, in which it was intended to take the paper from the roll and cut it the required length and width, in passing to and before it reached the printing cylinders. With this machine there was some difficulty, and the attempts made to run it were all failures.

Derriey-Dalloz continuous rotary job-press.

D. Hutinet, of Paris, had at work a machine for printing business and other cards in six colors, very simple in its construction and perfect in its operation. The card to be printed was forced against the plate by a crank, the six plates with the different colors being carried on a shaft, which was turned one-sixth of a revolution at each revolution of the crank-shaft by means of a cam motion, and the color-rollers passed over the plates by the same motion.

D. Hutinet chromatic printing-machine.

J. Jornaux, of Paris, exhibited the type-composing machine invented by Isidore Delcambre; Charles Kastenbein, of Paris, his composing and distributing machines; Patrick Adie, of London, Fraser's distributing and composing machines. These machines, so far as can be seen, are quite similar—the type being arranged, by the aid of the distributing machines, in tin troughs or flat tubes for the composing machines, in which they are arranged in a vertical position, and the type distributed by means of a key-board similar to that of a piano. They claim to set up from six to ten thousand types per hour.

Type-composing machines of—Delcambre, Kastenbein,

Fraser.

A. Trouillet.

One of the neatest exhibits of light machinery was that of numbering machines by Auguste Trouillet, of Paris. These machines are made for quite a variety of purposes,

Numbering machine.

the larger ones chiefly for numbering bank notes, railroad tickets, and election tickets, where the name of each voter is recorded and the number of the vote stamped upon the ticket. They are made upon the same principle as the counter in common use for counting the revolutions of steam-en-

Description.

gines and other machinery, are very compact, and of fine workmanship. To the first cylinder or units roller, upon which the figures are engraved, is attached a ratchet-wheel of 10 teeth, to which motion is given by a click, with a lever attachment. Each movement of the lever passes a tooth of the ratchet, and brings forward the next figure, until the 9 is reached, when a pin which passes through this ratchet and roller is brought in contact with a fixed inclined plane attached to the frame. In passing the plane, the pin is forced inward against a spiral spring, until its inner point is passed into one of ten spaces cut in the side of the second or tens roller, when it is carried along one space with the units, and the first ten is numbered. This is repeated until the number 99 is reached, when, upon the pin being forced in, its inner point comes in contact with a similar pin passing through the tens roller, which, in its turn, is forced through until its point enters one of ten spaces in the third roller, when it also is moved with the two first to number 100. The process is repeated to any number of figures required. Machines are constructed to number notes or tickets in sheets of any size. The high reputation of these machines is undoubtedly well earned. They are exquisitely well made.

Machines, machine-tools.

Machines, machine tools.

One of the largest classes was that of machinist's tools, in the French section alone there being about 100 exhibitors. The tools generally were just such as may be seen in any of our machine shops.

Quick-return motion for shaping-machines.

Quite a variety of "quick-return motions" were to be seen on the shaping machines, but it is more than doubtful whether any of them is as good as that made by Mr. Whitworth on the original machine.

Planing-machines.

Of planing machines a large number were on exhibition, varying in size from the smallest hand machines to the

Varrall, Elwell, & Middleton.

large power machine of Messrs. Varrall, Elwell, & Middleton, of Paris, which was capable of planing a piece from 8 to 10 feet square and 25 to 30 feet long; very English in style and finish, as were all the tools exhibited by this firm.

The method of lubricating the slides was novel and good. In the Vs of the bed-piece, at a distance of some three feet apart, pockets were made, in which were placed rollers of five inches diameter, turned to fit the surface of the Vs on the table.

Planing-machine. Varrall, Elwell, & Middleton.

These rollers were on small journals, and apparently held up by springs so high that they were brought in contact with the Vs of the table, and by this contact made to revolve while the table was passing over them. The pockets were filled with oil as far up as the center of the rollers, which in their revolution carried it up and deposited it on the Vs of the table, making the lubrication perfect. This planer was one of the very few tools on exhibition that were put in motion.

Description.

There did not appear to be nearly so much attention paid to what might be termed the convenient handling of the machine tools as with us. What was called a Sellers planer had the belts placed at the side opposite the workman, and the pulley or first driving shaft at right angles to the bed, making it necessary for the workman in cases of nice adjustments of the cutting tools to climb over or walk around the machine to reach his belts, and entirely losing sight of the object Mr. Sellers had in view while designing the machine, that of driving it in a position parallel with the line shaft.

As to the convenient handling of the machine tools.

Lathes were shown in large numbers, differing from our own only in the almost universal use of gearing with helicoidal teeth, very carefully made. They must run quietly, but not one was to be seen in motion.

Lathes.

The most marked difference between the machinery in the Exposition and American machinery was the use in the European of gearing with helicoidal teeth or "Hook's gearing." It was to be seen in machinery of almost every description, from the heaviest to the lightest. For cutting this gearing, and the patterns for it, M. A. C. Piat, of Paris, exhibited a machine which was stated to be "not for sale," but merely an addition to his own plant. It was a large and rather complicated affair, the novelty consisting in its having two worm-wheels on the spindle carrying the wheel to be cut, one of which is used only for dividing, the other for revolving the work while the teeth are being cut. The worm-shaft of the first or dividing wheel is attached to the second or feed wheel, so that both the dividing and the feed wheels move together with the spindle while the feed is in gear and a tooth is being cut. After the cut is made the cutter is withdrawn, the feed reversed, and all the parts

Use of helicoidal teeth gearing.

A. C. Piat.

Machine for cutting helicoidal teeth gearing.

Machine for cutting helicoidal teeth gearing.

return to the positions occupied when the cut was started; the change-wheel on the worm-shaft of the dividing-wheel is brought back into gear with the dividing-train; the division is then made, and the work goes on.

Bariquand & Son.

Very handsome small machine tools were shown by Messrs. Bariquand & Son, of Paris, with specimens of their work in parts of the Chassepôt gun.

H. C. Lucq.

H. C. Lucq, of Pont-sur-Sambre, had a class of tools made for the use of blacksmiths, locksmiths, etc., consisting of upright drills, to be driven by hand or power or both, as might be desired; hand-punches, hand-shears for cutting plates and round or square iron. They were all light and well made, the drills particularly well adapted for the use of small country or city shops, where nothing but hand-power is used.

Drills, punches, and shears.

Sir Joseph Whitworth.

Sir Joseph Whitworth & Co., and Sharp, Stewart, & Co., both of Manchester, had some of their tools, in which, although there appeared to be nothing new, there were, as there usually are, very fine specimens of good workmanship.

Sharp, Stewart' & Co.

Sharp, Stewart, & Co. had a machine to be driven by hand or belt for facing the valve-seats of locomotives or other steam-engines in position, with various other tools for repairing locomotives.

Machine for facing valve-seats.

Whitworth & Co.

Whitworth & Co. exhibited a hydraulic machine for testing the tensile strength of metals. The bar to be tested was enlarged and screwed at each end, screwed into the machine, and the force applied by means of a pump operated by hand, the strength being indicated by a pressure gage, and its ductility by the difference in the length of the test piece before and after it is pulled apart. They also showed a beautiful self-acting foot-lathe with steel-hardened spindle in steel-hardened bushings; a large assortment of screw-cutting tools, both for hand and machines, in which they still adhere to the thread with round top and bottom; two pairs of surface plates, with their well-known measuring machine, and cylindrical gages.

Hydraulic testing-machine.

Tools, test-plates, and gages.

Julius Hall.

Julius Hall, of London, had a drill (partially exposed) for drilling, or more properly milling, a square hole out of the solid, in wood or any of the metals. An ordinary hand-drilling machine was used. The cutting end and the section of the shank of the drill was an equilateral triangle, the side of which was equal to the side of the square hole to be bored, and the shank made of sufficient length to allow the cutting end while revolving to follow the sides of a square hole of the same size as the hole to be bored, used

Drill for making square holes.

as a guide. In the state in which the square-hole drill was exhibited it is more of a curiosity than a useful tool.

Milling machines.

Large numbers of milling machines were on exhibition, with nothing whatever about them giving the slightest claim to novelty or to any particular notice.

Emery wheels and grinders.

A very extensive display was made of emery wheels, from the size of an ordinary grindstone, 3 or 3½ feet in diameter, down to ½ inch in diameter, with machines especially adapted for their use—for sharpening cutting tools, grinding flat and cylindrical surfaces, to correct the inaccuracies of the lathe and planer, and others proposing to do away entirely with steel-cutting tools and finish their work from the rough. The best machine of this class of machine tools was that of the Brown & Sharpe Manufacturing Company, of Providence, R. I., for grinding and finishing flat surfaces, well adapted for grinding steel surfaces, hard or soft, such as the faces of punches and dies, straight edges, and many small tools in common use. None of these tools were put in operation, so that there was but little to guide one in judging of their merits, except his own experience.

Brown & Sharpe Manufacturing Company.

Cutters, tools, rules, and gages.

The Brown & Sharpe Company made a very handsome display of their small tools, such as cutters for gear-wheels, taps, reamers, drills, etc., with steel rules, squares, and gages of various descriptions.

Jackson & Bro.

Messrs. Jackson & Bro., of Bolton, England, exhibited Scott's patent-wheel molding and gear-cutting machines, with J. C. Scott's patent dividing apparatus. The object is to keep the dividing-wheel down to a moderate diameter, and to do away with change-wheels. The dividing was done in the usual way by means of a worm and worm-wheel. The fractional parts of a revolution of the worm-shaft were regulated by movable steps on a circular disk, through which the worm-shaft passed. A latched crank-arm, by means of which the worm-shaft was turned, was clipped to the shaft, so that it might be readily slacked up and returned to its original position after the fractional part of a revolution is made. Judging from the number of exhibits of gearing made without patterns to be seen in different parts of the Exposition, these wheel-molding machines must be very generally used.

Scott's wheel-molding and gear-cutting machines.

Dividing wheel.

Aiken & Drummond.

Molding machine.

Messrs. Aiken & Drummond, of Louisville, Ky., had on exhibition a hand or power molding machine for foundry use, which is no doubt a useful tool, although its capabilities could not be properly shown. This machine was intended to mold such work as gas and water pipe fittings, cocks, valves, and other plumber's goods, axle-boxes, sash-

Aiken & Drummond. Molding machine.

weights, sad-irons, and all castings of such character. It is said by the exhibitors that it is capable of turning out four times as much work as can be done by one man on a hand-bench; that no skilled labor is required, as the machine sets the patterns, draws them, and rams the sand; that it being unnecessary to rap the patterns or sponge the molds, the castings produced are exact duplicates of the patterns.

R. H. Tweddell Hydraulic Engineering Company, of Chester. Hydraulic machinery. Riveting-machines.

Very handsome exhibits were made in the British section by R. H. Tweddell, of London, and the Hydraulic Engineering Company, of Chester, of hydraulic machinery, consisting of accumulators; pumps for accumulators, with automatic arrangements for stopping and starting them by the accumulator; a stationary riveter for boiler work; portable riveters, with their cranes and connections, for riveting girders or bridge work in position, etc. The power was transmitted to the portable riveters through coils of copper pipe in place of the jointed pipes used heretofore, one coil leading from the mast of the crane to the carriage on the jib, and an ther coil from the carriage down to the riveter. The coils opened or closed as the parts were moved in and out or up and down, and, having no moving joints, were always tight under all pressures.

Stone-dressing machine.

Stone-dressing machines.

Brunton & Trier. Description. Capacity of the machine. Planetary motion of the cutters.

The most remarkable labor-saving machine was that of Messrs. Brunton & Trier, of London, for dressing stone by means of revolving cutters. The machine exhibited (Class 50) was made for dressing flat surfaces on freestones and limestones. It consisted of a heavy headstock, A (Figs. 1 and 2), supporting the shaft which carries the chuck B, with a bed and table similar to those of a planer for holding the block of stone and feeding it across the face of the chuck. There are twelve cutters in B, each 12 inches in diameter, made of cast iron, with chilled cutting edges; they incline inwards, and cut the stone with their inner edges. The track described by the cutting edges was a circle 6 feet in diameter. The machine could therefore dress a stone, say, 5 feet wide, and of any length the bed might be made to carry. The new feature in this machine lies in the fact that the cutters, in place of rolling over the surface of the stone by their contact alone, are forced, by means of gearing inside the chuck, to revolve at the same circumferential velocity as that with which they are passing over the stone —about 2,500 feet per minute; while, if they were dependent upon their contact with the stone for their rotation, a very slow motion only would be possible. The chuck is driven

by a belt on the pulley C, and the relative rotation of the cutters controlled by a belt on the pulley D. The stone was fed across the face of the chuck at the rate of from 3 feet 6 inches to 3 feet 9 inches per minute. While in use the chuck is kept nearly half full of soap and water, for lubricating the bearings and gearing driving the cutters. The machine running at the Exposition was dressing brown-

Brunton & Trier's stone-dressing machine.

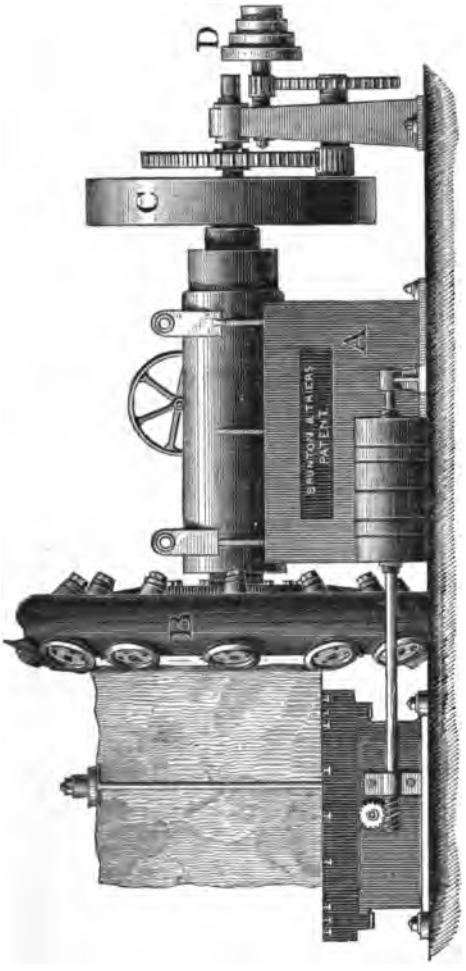


FIG. 1.—*Brunton & Trier's stone-dressing machine.*

Stone-dressing machine.

stone, and performed its duty rapidly and well, the cutters being set to cut in three steps; but four out of the twelve were finishing the face, requiring from 10 to 18 horse-power to drive it, depending of course upon the speed at which the chuck was driven.

Description.

Machines are made of different sizes and designs to suit various purposes. That shown in Figs. 3 and 4 is so ar-

Brunton & Trier's stone-dressing machine.

ranged as to cut with the outer edges, with a track 18 inches wide, and having a vertical adjustment of the chuck to cover a wider surface if necessary. Some of the work of this small machine in granite was exhibited, which was very

Stone-dressing machine.

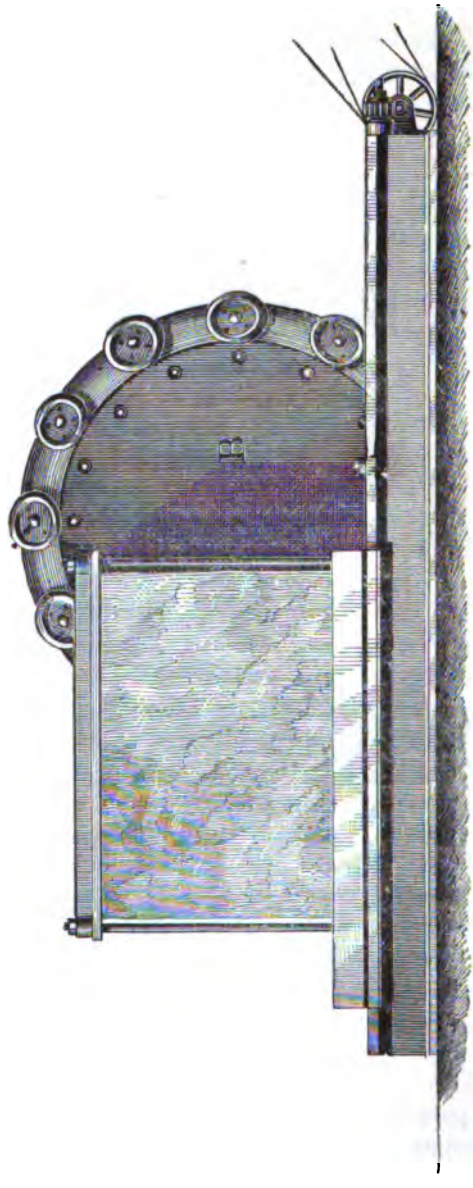


FIG. 2.—*Brunton & Trier's stone-dressing machine.*

Cutters of chilled iron or of steel.

well done, the exhibitors claiming to work it expeditiously and cheaply, using steel for their cutters in place of the chilled-iron ones used on softer stones. The cutters while at work did not get hot, and kept their edges perfectly well.

Belting.

Belting.

Very fine specimens of leather belts were shown in different sections, some of extraordinary width, of double and triple thicknesses.

The immense belt of J. B. Hoyt & Co., of New York, exhibited in the United States section, was a handsome and well-made piece of work, and, to say the least, was unsurpassed by those of any other section. Thomasset & Driot, of Paris, exhibited belts made principally of hair, said to

J. B. Hoyt & Co.

Thomasset & Driot.

Hair belts.

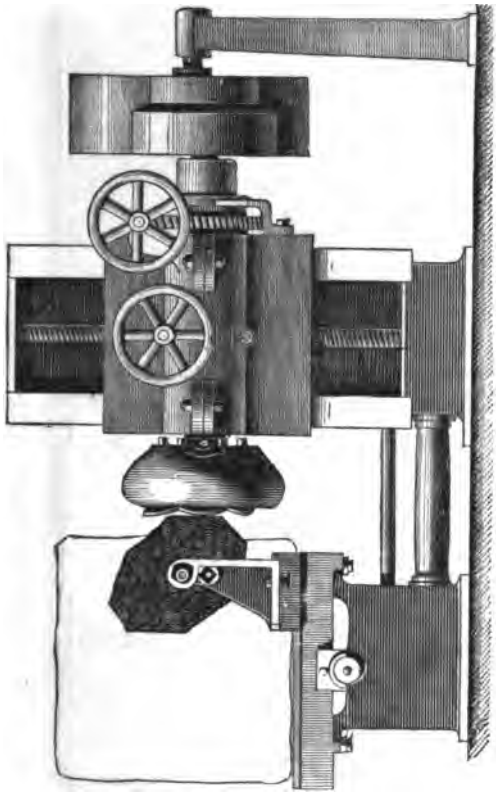


FIG. 3.—*Brunton & Trier's stone-dressing machine.*

Stone-dressing machine.

be more elastic and to possess double the strength of leather. They are made for special purposes, and would certainly be too expensive for common use.

The mode of driving mills, factories, etc., by means of gearing seems now to be in a fair way of being abandoned in Europe, and that adopted in this country many years ago, of driving by main belts, substituted in its place. The power was taken from many of the large stationary steam-engines running in the Exposition by hempen ropes of 2 inches diameter, the fly-wheels on the engines and the pulleys receiving the power being grooved for the ropes. Each rope

Driving belts superseding gearing.

Rope substitute for belting.

is said to be capable of delivering 23 horse-power when moving at a velocity of 2,000 feet per minute. The use of ropes is recommended because they are cheap in first cost, because they are light and durable, many of them having been in constant use for ten years without material deterioration.

Stone-dressing machine.

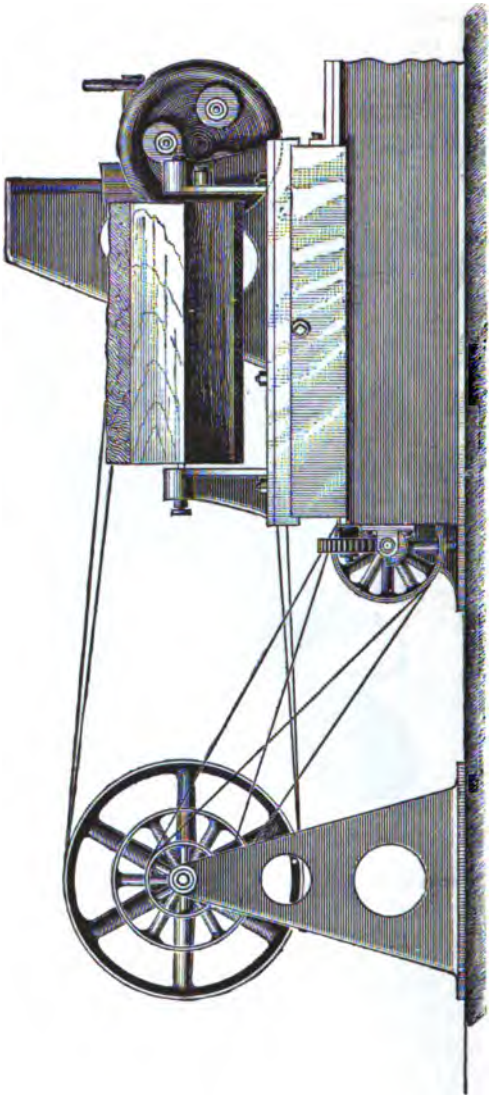


FIG. 4.—*Brunton & Trier's stone-dressing machine.*

In conclusion, I have to say that I regret being unable to get more out of this great collection of machinery that would be practically useful to our mechanics.

WM. T. PORTER,
Additional Commissioner.

CLOCKS AND WATCHES.

EDWARD H. KNIGHT, LL. D.

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REPORT

ON

CLOCKS AND WATCHES.

There were nearly six hundred exhibits in Class 26 (*Horlogerie*), more than four-fifths of them being contributed by France and Switzerland. The other countries represented were England, Austria, Spain, Denmark, Belgium, Holland, Sweden, Italy, Russia, and the United States of America. France and Switzerland presented collective exhibits of their watch manufacture, but no collective exhibits were made in this class by the other countries, for the simple reason that the number of entries from each was not sufficient to constitute such a display. The United States had but six entries in the class. There were three exhibits of clocks, the Seth Thomas Clock Company, the Ansonia Clock Company, and the house of F. Kroeber being represented. There was but one exhibit of watches—that from the factory of the American Watch Company—and its magnitude, variety, and excellence attracted general attention. Hagstoz & Thorpe had an exhibit of watch cases of peculiar construction, and E. J. Meybridge, of San Francisco, a pneumatic clock. This completes the list of American exhibitors in Class 26. The six exhibits received no less than six awards.

Number of exhibits in Class 26.

Countries competing.

Collective exhibits from France and Switzerland.

United States exhibits: Seth Thomas Clock Company. F. Kroeber.

American Watch Company.

Hagstoz & Thorpe.

E. J. Meybridge.

The awards to American exhibitors were as follows:

Awards to United States exhibitors.

Gold medal.

American Watch Company.....Waltham, Mass.

Silver medal.

Seth Thomas Clock Company.....New York, N. Y.

Bronze medals.

Ansonia Clock Company.....Ansonia, Conn.

Charles Vander Woerd (Collaborator), of the American Watch Company.....Waltham, Mass.

Hagstoz & Thorpe .....Philadelphia, Pa.

Honorable mention.

F. Kroeber.....New York, N. Y.

Owing to the difficulty of properly demonstrating the work of the curious and minute special machinery, by the

Comparison of the American Watch Company's exhibits in Philadelphia and Paris.

attendance of skilled and accustomed operatives in a foreign country, the American Watch Company did not repeat the interesting feature of its Centennial display by showing the watch in process of manufacture, but restricted itself to an exhibit of the finished watch in many forms and of the various parts ready for assembling.

The exhibits of France and Switzerland the most extensive.

Naturally, the exhibits of France and Switzerland were much more extensive than those of the same countries in 1876. The exhibit of France was noticeably in advance of any previous display of that country in horology. The watchmakers of the Département du Doubs and the clockmakers of Paris were well represented, the latter winning the admiration of the jury for the beauty and perfection of their work. The *pendule de voyage*, or traveling clock, was displayed in great variety by many exhibitors and there were fine specimens of heavy clocks for church towers and similar places, and of clocks that would operate for long periods with a single winding. Clocks to run a month were numerous, and there were several that would run a year. One exhibitor presented a clock that needed to be wound but once in fifty years, and another a clock with a complication of springs that was guaranteed to keep it in operation for a thousand years. Owing to the brevity of the exhibition and other causes the jury was unable to make a practical test of the correctness of the claim in these two cases. There were clocks propelled by water, others by electricity in several ways, and clocks that moved orreries of great comprehensiveness and elaborate construction. In the Austrian section the pneumatic apparatus designed to operate dozens, hundreds, or even thousands of clocks in all parts of a large city was exhibited, and an arrangement that somewhat resembled it was brought to the American section too late to be entered for competition. In the French section there was a clock on the decimal system; it divided the day into ten hours, begining at midnight, and this hour was then divided into tenths. The tenths of hours were divided again, and then there was another division of tenths that brought the measurement of time down to a fine point. The clock was well constructed and the principle on which it was built was easy of comprehension; it was a natural outgrowth of the metric system of weights and measures, but did not meet with favor in the eyes of the jury.

Pendule de voyage.

Tower clocks.

Clocks for running long periods without winding.

Electric clocks.

Orreries.

Pneumatic clocks.

Metric system clocks.

Swiss exhibit, by cities and cantons.

The Swiss exhibit was arranged according to cities and cantons, so that the study of the work of any particular section was greatly facilitated, and the same was the case to a less extent in the French section. The manufacturers of

watches in the Département du Doubs sent nearly two hundred separate lots for making up their collective exhibit, but many of the lots were very small and of little value. The French watches were not conspicuous for their excellence, either in movements or cases, and the same remark will apply to some of the Swiss productions. The most creditable watches in the Swiss section were from Geneva, with a few exceptions, while the best from the French makers were from Paris rather than from Besançon. Watches of a high order were presented by Audemars, Ekegren, and other Geneva makers, and watches equally good by Leroy, of Paris. Some of the specimens were a marked advance over anything shown at previous exhibitions, but on the other hand there were many exhibits, more than a majority, that evinced no progress whatever. The endeavor to make a watch that would perform many functions seems to have reached its limit in 1878. Watches that would tell the days of the month or week and show the changes of the moon were in abundance, but they are far from new, as the principle was adopted many years ago in the Dutch clocks that are to be found in many houses, where they have stood half a century and more. There were watches that would sound alarms at a given time, not only by the old system, but by the discharge of a pistol or letting a heavy body fall to the floor. There were watches that would show the difference of time between any two or more of the great cities of the world, and there was one watch that seemed able to rival the performance of Bowditch's Navigator in working problems of latitude and longitude. There was a watch no larger than a silver dime that was certified to be an excellent timekeeper, and struck the hours and half hours; and there was another watch that showed how energy and intelligence may be wasted. The entire movement was of rock crystal; the maker had been five years over its construction, and admitted that it was not a good time-piece and that he never expected it would be. In the Russian section there was a clock which had occupied its maker twenty years to construct; it had a musical attachment, and when in operation it set in motion a lot of dancing figures and caused buds and flowers to open and close.

Département du Doubs.

Character of French watches and Swiss.

Watches with many functions.

Alarm watches.

Comparative time watches.

Minute watches.

Watch of rock crystal.

Musical watch.

The single exhibit of watches in the American section attracted more attention than any other display in horology, partly owing to its extent, but mainly to the fact it was an exposition of the product of machine work. In France and Switzerland but little machinery is used, and the few machines now in operation are either of American manufacture

Interest in the American watch machinery.

European method of watch-making.

or copies of the inventions of Americans. The custom of those countries is to make the different parts of a watch in almost as many shops as there are pieces, and it is safe to say that there is not and never has been an establishment either in England or on the Continent where the whole work of making a watch is performed under one roof. Sometimes

Divided hand-labor in many houses.

the places of manufacture are far apart, and the workmen employed on one kind of pieces never see or hear of those engaged on another. A man who calls himself a manufacturer buys a quantity of the finished pieces, and then groups them together to form a watch, and a great deal of filing and polishing is necessary to make the different parts fit each other. Each workman must have his profit, however small, and this amounts to a considerable sum when multiplied by the number of persons engaged on a watch. Then the manufacturer's profit must be added, and altogether they serve to bring the product to a high price as compared with its worth.

American machine system.

In the machine system, established by the American Watch Company, the parts of the watch are all made by machines in the factory of the concern; from the crude material to the finished movement, beating time by regular pulsations,

The whole work systematized in one establishment.

the whole operation is concluded within the compass of a single set of brick walls. At the outset the purchase of the material gives room for a considerable saving, as the brass and other metals needed for a dozen watches must necessarily be much higher in proportion than the same articles for ten thousand watches. Then, if the ten thousand can be constructed on the same model and with no variation whatever in the identical parts, the cost of making the

Parts made to gage.

various pieces necessary to the formation of a watch will be considerably reduced. The principle adopted by the American Watch Company is the same that has long been ap-

The American system in making fire-arms, sewing-machines, &c.

plied to the manufacture of fire-arms, sewing machines, agricultural implements, and other things both in this country and in Europe. It had its origin in America in consequence of the high price of labor, which compelled manufacturers to devise some mode of competing successfully with the

Large results by labor of one one man on a machine.

cheaper labor of Europe. Machines that with the assistance of one man could do the work of five or ten were the result, and the labor competition was achieved. But it was found that the machine did better work on the average than the skilled workman, or rather that there was no average about it, since each piece that the machine turned out was

Assembling.

exactly like every other. The various parts for a thousand rifles could be thrown in a heap, and, on picking out enough

to form a single rifle, they were found to fit perfectly, a result that could never be accomplished under the old system of hand labor. This was an unlooked-for advantage; the inventors of the machinery had thought only of saving labor, and it is doubtful if a single one of them in the early days had ever considered the possibility of a machine that would do better work than the skilled artisan. Assembling.

A general description of the American Watch Company's works at Waltham, Mass., and an account of the sequence of operations in detail, may be found in the report by the present writer as Chairman of Group XXII on the International Jury at the Centennial Exhibition at Philadelphia, 1876. Pages 46 to 53, Report of Group, XXII. Reference to Centennial Report of Group XXII.

When it was proposed, thirty years ago, to apply this system to the manufacture of watches, the scheme was received with incredulity. Machines might construct the parts of a rifle or a sewing machine, a reaper or a locomotive, but they could never perform the delicate operations needed for the manufacture of a watch. How could a machine be made to turn out screws so small that a microscope is necessary to examine them distinctly, and wheels of such dimensions that the variation of the thousandth of an inch would seriously affect their action? Especially incredulous was the watchmaking world of England and the Continent, and the failure of the new enterprise was confidently predicted. It began in 1850 by the organization of the "Boston Watch Company," with a factory at Roxbury and later at Waltham. The incredulous were right, and the enterprise became bankrupt in a few years. The watchmakers of Switzerland had heard of the enterprise with some misgivings, but they were not seriously alarmed, and when the crash of the Boston Watch Company came in 1857 it was nothing more than they expected. The cause of this failure, however, is not to be ascribed to the system which it was the endeavor of the originators to introduce, but to lack of management and to the great crisis of that year, sinister to so many commercial and industrial enterprises. But the purchase of the property by R. E. Robbins, of New York, for the firm of Appleton, Tracy & Co., and the subsequent organization, under the laws of Massachusetts, of the American Watch Company, with a capital of $200,000, showed that there were other Americans than the unfortunate pioneers who believed that watches could be made by machinery. From this beginning has grown the present establishment, with a capital of $1,500,000 and a surplus of $500,000, that employs 1,300 persons and turns out in a single year 150,000 watch move- First attempt to apply the system to watchmaking. Boston Watch Company, 1850. Failure and cause. R. E. Robbins. Appleton, Tracy & Co. American Watch Company. Capital. Labor. Products.

Watches all imported previous to 1850

ments and half that number of cases. Before 1850 all the pocket time-pieces used in America were imported—the far greater part of them from Switzerland—and for several years the importations were very little affected by the American manufacture. But the business grew and prospered, as it was found that the American watch was better than the foreign one at the same price, owing to the superiority of the machine work when compared with hand labor.

Superiority of machine work.

Reduction of price.

Prices were reduced, and it became possible for a person of very moderate means to carry a reliable watch in his pocket, and he had the satisfaction of knowing that in case any part of it should become broken, duplicate pieces were accessible that would fit exactly. It would only be necessary to send the number of the watch to the factory, with a description of the damaged piece, and the return mail would bring the duplicate, which could be put in place in a few minutes by the most ordinary repairer of watches.

Duplicating damaged parts.

Effect on Swiss and French importations.

The Swiss and French watchmakers heard of the enterprise from time to time, but continued to deride it until they found that their trade was falling off; the American importations of Swiss watches were diminishing in spite of the growth of population and the increasing prosperity of the country. Not only were they losing the American trade, but the Americans were attacking them in other markets.

American trade extending abroad.

They were selling watches in India and Australia, and then they went with their machine-made wares to England and opened a house in London. Failure of this enterprise was predicted quite as confidently as the original failure had been predicted in 1850; but somehow it succeeded, and it was not long before 20,000 to 30,000 watches were sold every year in England and the prospect growing better every day. The decline of the importation into America of foreign-made time-pieces is shown by the following official figures of the export of Swiss watches to the United States for a period of five years:

Sales in England.

Importation of Swiss watches, 1870–1875.

In 1870	330,000
In 1871	342,000
In 1872	366,000
In 1873	204,000
In 1874	187,000
In 1875	134,000

The Swiss aroused.

These figures alarmed the Swiss makers, and in 1875 they determined on a fine display at Philadelphia in the following year, and also arranged to send some of the most intelligent of their number to report on the American industry and the causes of its rapid growth and general success. On

his return to Switzerland the Swiss judge at the Centennial Exhibition, M. Favre-Perret, reported that the American manufacture had reached such a stage that the United States could henceforth be supplied without importations from abroad. He openly declared that the ruin of the watch-making industry of Switzerland was impending in consequence of the competition of the Americans, and admitted that he could not point out a remedy. His report caused a great sensation among the watchmakers of France and Switzerland, and as soon as it was known that the American Watch Company would have an exhibit at Paris in 1878 there was a universal desire to see it. The excellence of the display was freely admitted both by experts and the general public, but there were many who were slow to believe that the watches shown in the American section were made by machinery, and they were staggered by the information that a single company should employ over 1,000 workmen, engaged in directing the machines by which the watches were made. The jury of the class was composed of four representatives of France, three of Switzerland, one of England, and one of the United States of America. The official examination of the American exhibit was left until the exhibits of all other countries had been visited, but during the period of their labors the members of the jury informed themselves fully of the character of the American display, for the purpose of making comparison with others.

The Swiss commissioner of the Centennial; M. Favre-Perret.

His report to the Swiss.

Exhibit of the American Watch Company in Paris.

The jury in Class 26.

By the figures given to the jury, it was shown that the watch industry of Switzerland turns out an average of 40 watches annually for each workman employed, while the average in the United States is about 150, and therefore the machine, with one man to direct it, can perform the work of four men. The machine does not demand any wages beyond the interest of the capital invested and the outlay to keep it in repair; it never enrolls itself in a labor union and threatens a strike; and it never spends an evening at a corner grocery, to appear on the following morning with an unsteadiness of nerves that is particularly out of place in watchmaking. The advantage of economy and excellence of performance on the part of a machine was recognized by the jury, and if any of them had been skeptical, the watches were before them to give testimony of the products of machine labor.

Average of watches per hand by the European and American systems.

Advantages of the machine work.

It is to be regretted that no test was made of the performances of watches of the higher grades. Several exhibitors asked for one, but the jury decided, after careful deliberation, that the circumstances under which they were assem-

No tests made in Paris for the higher grades.

bled and the short time allowed for the performance of their labors did not justify such a trial. Many of the Swiss makers had the official bulletins of the performance of their watches at the observatories of Neuchâtel and Geneva.

Value of the Swiss observatory tests.

The establishment of these observatories has done a great deal to stimulate the Swiss watchmakers to reach a higher degree of excellence, and it is clearly demonstrated that they have made greater progress toward perfection in watchmaking since the observatories began their work than ever before in the same time. It is to be hoped that the Govern-

As to the United States affording means for official tests of performance.

ment of the United States will not be altogether unobservant of the example which Switzerland has set; it is highly desirable that an official character should be given to all watches of the highest grades, both as a guarantee to the purchaser and a stimulus to the manufacturer. In the Swiss observatories the trials last for six weeks, and the watches are tested for position and temperature; the latter includes both heat and cold, the first being made in an oven

Reference to the tests made by the jury at the Centennial.

and the second in a refrigerator. A comparison of all the bulletins presented at the Centennial Exhibition, 1876, showed that the American watches, in two instances, had surpassed the best performances of the Swiss watches of the

Report of Prof. Watson, of Ann Arbor.

same grades in all the various tests, and one of them showed a difference of mean daily rate between the first and last week of the trial of only one-hundredth of a second.

Gradual adoption of machinery in France and Switzerland.

In the lower grades of watches it was admitted by many of the Swiss and French makers that machinery could be made of great advantage, and some of them have been using it for this purpose. One firm in France has adopted the American system, and is turning out a large number of watches by means of it, but they are only of the very lowest order, and considerably inferior to the cheapest watches of the American Company. The work is of the rudest char-

Used in making a cheap and common watch.

acter, and there is very little attempt at finishing the parts so that they will run smoothly against each other. Several firms in Switzerland are using machinery in a small way, but it is unpopular with their workmen in consequence of its interference with customs that have existed for a great number of years.

Compensating balance of Chas. V. Woerd.

The jury was much interested in the compensating balance invented by Mr. Charles V. Woerd, the mechanical superintendent of the factory of the American Watch Company, and promptly awarded him a medal as a collaborator whose work deserved recognition. The form of compensation hitherto employed in the balances of watches and chronometers can be made perfect only for two critical temper-

atures, while for intermediate or extreme temperatures the compensation is imperfect. Devices called secondary or auxiliary compensation have been applied to remedy this defect in a partial degree. The effect of the temperature is to modify the elastic force of the spring as well as to change its length and to change the form of the balance; perfect compensation requires that the time of vibration of the balance shall be constant under all the vicissitudes of temperature to which the instrument may be subjected. This requires an arrangement of the parts so that the moment of inertia of the balance shall maintain a constant ratio to the moment of the elastic force of the balance spring. The law of the change of the effective elastic force of the spring is not absolutely determined, but sufficient is known about it to make certain that the compensation cannot be made perfect except at two temperatures. The expressions of the variations of these moments in respect to the temperature give, when graphically represented, two curved lines, and the adjustment can be made only for the two points where these curves intersect.

C. V. Woerd's compensation balance.

The problem.

Mr. Woerd's device consists in the substitution of an entirely different arrangement of bimetallic laminæ in such a way that the ratio of the moments of the balance and of the spring shall remain constant during all the temperatures to which the watch or chronometer shall be subjected while in use. He employs steel for the inner lamina, as usual, but for the outer he uses a composition of higher expansibility than the brass which has been hitherto employed. Instead of two parallel and connecting laminæ he uses only a short arc of the outer composition, and this is connected with the steel in the form of intermeshing teeth that are solidly fused to it. The outer edge is turned down so that the edges of the steel teeth separate the composition into a succession of prisms. By this means the action is different from that of continuous bimetallic laminæ in avoiding the constrained action of the laminæ and providing for that freedom of movement of the compensating weights which is necessary to fulfill the actual requirements of the adjustment for temperature.

Description.

Another advantage which this invention possesses is that it is always possible to find the teeth in the bimetallic part that are necessary, in connection with the proper compensating weights, to make the motion of these weights correspond with the requirements of the balance spring for autochronous vibration at different temperatures. In order to lighten the steel rim and keep the effective weight of the

Advantage.

C. V. Woerd's compensation balance.

balance as near the rim extremities of the segments as possible, Mr. Woerd drills one or more holes in the steel rim, and intermediate between the bimetallic part and the compensating weights, so that the desired effect may be produced by a limited arc of the two metals. This device also provides for a delicate adjustment of the poise of the balance far more easily than by the old method. Altogether it is confidently claimed by Mr. Woerd that the mean error under his form of balance and the manual adjustment required will be reduced to a third of that now obtaining under the old system. The results that have been obtained by this form of balance have been most gratifying. The first experiments were made with 60 watches equipped with it, and the reduction of time required for adjustment fully justified the claim set forth above.

Valuable result.

Former and contemporaneous attempts at resolving the problem.

It frequently happens that an invention appears simultaneously in two or more places, the work of as many men, who have been working quite independently and generally ignorantly of each other to accomplish a certain result. In the present instance Mr. Woerd finds that two Swiss watchmakers have been studying to make a balance that should obviate the defects of the old form, but they have not yet hit upon a satisfactory result; and investigation shows that as far back as 1829 the question was discussed in France and Switzerland and also in England, and a variety of devices for overcoming the difficulty were proposed. In all, three men are known to have been at work, quite independently, to construct a balance that should give, at least in theory, a perfect compensation for all the natural temperatures to which a watch or a chronometer is subjected. Success in the effort has been first achieved by an American citizen, and his success is to be attributed, in a measure, to the system of making watches by machinery, as the delicacy of construction required for the balance is not possible except with the mechanism in use at Waltham.

Discussion in 1829.

Micrometer gage.

A micrometer was shown at Paris by the American Watch Company, which measured the 25-thousandth part of an inch; and a paper was submitted describing a micrometer screw-gauge constructing at Waltham, that would detect inequalities in the thread of a screw up to hundred-thousandths.

Value of international exhibitions illustrated.

The value of international exhibitions in advancing industry can have no better illustration than in the case of the American Watch Company. Its manufacture and sale of watch movements in 1877, the year following the Philadelphia Exhibition, showed an increase of about 18 per cent.

Illustration of the value of international exhibitions.

over 1876, and a statement recently received from the managers is to the effect that the business of 1879 was an increase of 43 per cent. over that of 1878, the year that the company exhibited at Paris. Of course a portion of this increase in 1879 is due to the revival of business, but the same cause did not operate in 1877, and we may safely credit the half at least of 43 per cent. to the effect of the Paris Exposition. And the increase is not confined to watches of the lower grades out of the ten varieties produced by the company. The demand for the highest class of watches is even proportionally ahead of that for the low-priced qualities, and indicates that the world is learning that it is no longer necessary to patronize an European maker in order to secure an accurate timekeeper for the pocket.

EDWARD H. KNIGHT,
Honorary Commissioner.

RAILWAY APPARATUS.

WILLIAM A. ANDERSON.

[Extract from the Official Classification.]

CLASS 64.—RAILWAY APPARATUS.

Separate parts: springs, buffers, brakes.

Permanent way: rails, chairs, crossings, switches, fish-plates, turn-tables; buffers, water cranes, and tanks; optical and acoustic signals.

Permanent way for tramways.

Rolling stock: wagons for passengers, for carrying earth, goods, cattle; locomotives, tenders.

Self-moving carriages; locomotives for roads.

Special tools and machines for the maintenance, repair, and construction of railways.

Apparatus for inclined planes and self-acting planes; apparatus and engines for atmospheric railways; models of engines, of systems of traction, of apparatus appertaining to railways.

Models, plans, and drawings of platforms, stations, and engine-houses, and other buildings necessary for the working of railways.

[This report includes a part only of the above subjects.]

REPORT

ON

RAILWAY APPARATUS AND MEANS OF TRANSPORT.

Great improvement in means of transport during the last decade.

In few departments of industry has there been a larger or more valuable advance during the decade just past than that which has been accomplished in the introduction of new and the amelioration of old processes, methods, and machines for transporting the products, traffic, and travel of the world. Even a cursory examination of the railway, tramway, and marine exhibits in the sections of France, Great Britain, Austria-Hungary, Belgium, Italy, Sweden, and the United States at the Paris International Exposition would suffice to satisfy the observer that while active brains and skillful hands have been working to great purpose on the western side of the Atlantic, the inventive genius and productive energies of Europe have been perhaps equally active during the last ten years in this important field of industry and progress.

on both sides of the Atlantic.

Wide range of the subject.

The subject of transportation, as exemplified at the Paris Exposition, embraced the whole of one of the subdivisions of the Exposition, designated as "Class 64, Railway Apparatus," a portion of the exhibits in "Class 54, Machines and Apparatus in General," and a large part of the exhibits in "Class 67, Navigation and Life-saving Apparatus." The subject, as briefly reviewed in this report, will be almost entirely limited to means of transportation upon land and by railways.

This report confined to railways and their rolling stock.

In respect to the exhibits relating to this subject, as well as to those illustrating the condition of navigation in the maritime countries of Europe, it may be said generally that the progress has been marked and most satisfactory, and of all it may be predicated that this progress has been more striking during the past ten years than in any like period since the general introduction of steam as a motive power.

Greater relative progress of the last decade.

Much of this advance may be ascribed to the introduction of improved machinery, of more scientific, more thor-

Cause.

Causes of the greater relative progress of late.

ough, and more simple appliances and methods, and better plans of construction in the vehicles of both land and water transportation; but the most potent factor in the amelioration which has been accomplished in this department of human enterprise has been steel—the general introduction of steel material into the construction of railway tracks, railway apparatus and locomotives, and the machinery of ships and boats propelled by steam.

Substitution of iron by steel.

New and improved steel processes.

Bessemer.

Siemens-Martin.

Krupp.

Schneider & Co.

John Cockerill Société.

Sir J. Whitworth & Co.

The great benefits resulting to the world from the cheapening of the cost of steel within the last decade by the more general introduction of the Bessemer, Siemens-Martin, and other analogous processes were conspicuously illustrated at Paris. The wonderful success achieved by Krupp at Essen, Schneider & Co. at Creuzot, John Cockerill Société at Seraing-lez-Liége, Sir Joseph Whitworth & Co. at Manchester, and others in manufacturing large and perfect pieces in cast and wrought steel, of immense strength and superb finish, has added greatly to the power, the security, and the durability particularly of machinery for propelling ocean steamships, while the general introduction of this metal in the construction of railway tracks, engines, and rolling stock has effected an immense and a permanent reduction in the necessary cost of railway transportation.

Increase in power, security, and durability of machinery, ships, railways, and plant.

Example.

A single example out of very many presented in the sections of France and Great Britain may be mentioned here as indicating what has already been realized from the substitution of steel for iron, and in some measure what may be expected in the future from the largely increased use of the better metal.

Durability of a steel rail.

A double-headed steel rail, made at the steel foundries of MM. Schneider & Co. at Creuzot, was exhibited by the *de* Western Railway Company of France upon the *Galerie la Bourdonnaye*, an annex to the French section. This rail had been in use, according to the certificate of the engineer of the railway company, for eighteen years, and 256,000 trains had passed over it in that period. The rail had only been used upon one side, and that was not yet half worn away. It was in an excellent state of preservation, and was estimated to still possess an expectancy of life, under like conditions of wear and tear to those experienced in its past history, of at least twenty years. When it is remembered that the average life of the iron rail, under circumstances much more favorable to longevity than those just mentioned, is less than seven years, the force of this example will be realized.

Life of a steel rail,

and of an iron rail.

RAILWAYS AND RAILWAY APPARATUS.

Railway progress in the United States

As there is no part of the world where railroads have been such an important agency in material development as in the United States, so it is gratifying to observe that nowhere else has there been greater progress in the art of railway construction or in the business of railway administration and management.

abreast of other countries.

Railways of the world.

Of the 185,000 miles of completed railways in the world in 1878, nearly one-half are in the United States. Having reference to territorial areas, this preponderance is very great, but as compared with populations it is enormous.

Proportion in the United States.

Our need of railways in subduing the continent to civilization.

With vast regions urgently demanding the speedy construction of new roads as the line of civilization has moved across the continent, with the needs of the older settled portions of the country not by any means fully supplied, and with that impatience of delay and eagerness of enterprise which are characteristic of the American people, it is not surprising that there should be much that is crude and superficial in many of the railway works of this country. But when we consider the relative cost of construction, the wants of a comparatively new and partially developed country, and the nature of the means available for railway construction, it will be found that American railroads, in the condition of their permanent ways and of their rolling stock, in their systems of administration, and in their efficiency, will compare favorably with those of any other country. In many regards they would not be so well suited to the countries and populations of Europe as the practice of railroad construction and management now usually prevailing in those countries. Indeed, the characteristics, social relations, and the wants of the people and needs of this country are so different from those of European nations that it is difficult fairly to contrast the European railway systems with the American. Particulars in which theirs would not be at all adapted to this country render them all the better suited to the needs of transatlantic populations.

Necessary crudeness of railways for developing unsettled country.

Comparison of administration.

Differences in tastes and habits between American and European peoples.

There are some things in the European railway practice which strike an American as inferior in convenience to the practice adopted in the United States, particularly their arrangements for the movement of passengers and their luggage. In Europe there is frequently a want of co-operation between different railway companies in the arrangement of through tickets over connecting lines owned by distinct companies, and the simple and convenient system of through-

Inferiority of European arrangements for transfer of passengers and baggage.

Our system of through-checking baggage.

checking baggage prevailing in this country is almost wholly unknown.

Arrangement of European cars and coaches.

There are other striking particulars in which the practice of European railways, their management of trains, their plans and arrangement of cars and coaches differ from the American railway system; but these are only different, and often equally good, modes for reaching the same results which are obtained in America by other and not superior methods. Their subdivision of their passenger coaches into *coupés*, or sectional compartments, each seating six, eight, or ten persons when full, and having no means of direct communication with each other or with the other cars of the train; their provision of retiring rooms at their stations, instead of having any such conveniences upon ordinary passenger and express trains, which appear at first awkward and inconvenient to persons accustomed to the American system, are not without their advantages. Their system of guards upon passenger trains, who do not control the movements of the train, their position being quite inferior to that of the American railway conductor; of managing their trains by telegraphic signals from the principal stations, as is the case upon some lines; of always requiring a passenger to have a ticket before allowing him to go upon a train, and of never allowing a fare to be paid upon the train, possess some advantages over ours. When we consider the character of the respective populations; the effects of class distinctions, everywhere so marked and so recognized in the Old World; the density of European populations and the comparative shortness of journeys, many of the objections which at first suggest themselves to the arrangements adopted upon European railways disappear.

Sectional compartments.

Retiring rooms.

The European "guard" as compared with the American "conductor."

Management of trains by signals.

Compulsory purchase of tickets.

Reasons for the maintenance of different systems.

Great precision and safety of the European administration.

There certainly is much to admire in the wonderful system and exactness with which hundreds of trains are daily moved upon the net-work of railroads in the vicinity of their chief cities. In these vast centers of dense population and enormous traffic the movement of trains and the transportation of passengers and freight are conducted without collision or confusion, with the regularity and precision of clock-work.

Substantial and convenient depots.

In the convenient arrangement and substantial construction of depots and depot buildings the Continental and British railways are generally abreast of the very best practice of the strongest and best-managed railroads of this country. In the regard shown for human life, the provision made at stations for crossing the tracks by bridges above or arched ways below the roadway; in the facilities pro-

Provisions for safety of life at stations and crossings.

vided for imparting to travelers trustworthy information as to routes and trains, and the courtesy of the railway guards and officials, some of the European lines set examples which it would be well for all railroad companies to imitate.

Courtesy and communicativeness of officials.

The general practice of European railways was illustrated at Paris by exhibits from France, Austria-Hungary, Great Britain, Belgium, Sweden, Italy, and Switzerland. There were exhibits from other countries than these, but none others which could be considered at all representative. It is to be regretted that the German Empire was not represented at all, for it is probable that the art of railway construction, equipment, and management has been brought to a higher degree of excellence in that great country than anywhere else upon the continent of Europe.

Countries exhibiting in Paris.

Germany not represented.

France, Austria, and Great Britain have been selected as the countries whose railway system and practice will be briefly reviewed in this paper. The exhibits at Paris from Belgium, Sweden, Italy, and Switzerland were all very inviting and creditable to the mechanical and engineering skill of those countries, and indicate a decided and healthy advance in the field of railway construction. It would be impossible, however, in the limits of this report, to do full justice to all, or indeed to any one, of the nations represented; and this review, which must necessarily be, to a great extent, partial, will be confined to the railways and railway appliances of the three countries mentioned, those of France and Austria being selected as representing the prevailing, and those of Great Britain the most advanced, types of European railway machinery and construction.

Review will be confined to the railway systems of France, Austria, and Great Britain.

FRANCE.

The French railway system dates its growth from the year 1840. It was first proposed to make all the roads the property of the state, but by law of June, 1842, it was determined that the work should be left to private enterprise, supervised and, in proper cases, aided by the government. The whole of the railroads of France were classed under two divisions, the *ancien réseau*, old net-work, and *nouveau réseau*, new net-work. The old system embraced the great trunk lines, which, as indicated, were the first built, and the new system the lines constructed generally as feeders to the trunk lines. These latter were often built rather from considerations of public utility than from any expectation of dividends upon the money invested in their construction. The roads of this latter class were aided by a government subvention in the shape of a guarantee of 4 per cent.

Commencement of railways in 1840.

Law of 1842.

Classification of railways.

Trunk lines and feeders.

Subventions for the latter class.

FRANCE.

interest, with 0.65 per cent. additional per annum, as a sinking fund for the extinguishment of the principal sum invested.

Extent of French railways in 1878.

There were 23,895 kilometers (about 15,000 miles) of completed railway in France in 1878, an increase of 8,000 miles since 1866. In 1875 there were 12,400 miles completed. The

Receipts for 1878.

total gross receipts of all the railway companies of France for that year were $162,847,105. The average receipts per mile for that year were $13,132. Maximum receipts per mile, those of the Northern Railway Company, "old net-work," were $30,032; and the minimum receipts (on some of the minor roads of the "new net-work") were for the same year less than $1,300. These returns present a view of a very well-conducted, steadily increasing, and fairly remunerative traffic.

The railway rolling stock and fixtures of the French railway companies have about kept pace with the extension of the lines of old roads and the construction of new lines.

Increased extent of railways and rolling-stock since 1866.

Since 1866, notwithstanding the losses occasioned by the war with Germany, the general railway system of France has been increased, exclusive of Alsace and Lorraine, about 64 per cent. The increase in the number of locomotives has been 54 per cent., in the number of passenger cars 41⅓ per cent., and in the number of freight, platform, and construction cars 69 per cent.

Nature of the improvements in way and plant.

The principal improvements to be observed in the construction of the permanent way of the French roads are the substitution of steel rails for iron; the general introduction of fish-bars; the use of cross-ties which have been treated with creosote, sulphate of copper, or some of the other processes for preserving them from decay. Experiments have also been made by some of the companies in the use of metallic cross-ties with some promise of success. Progress in the following particulars is also worthy of mention:

Block-system of signaling and running trains.

(1) The introduction of improved systems of signaling, by a combination of the "block" with the telegraphic system of signals, so that the movement of the switches by an automatic arrangement will necessarily correspond to the signals given.

(2) The general use of the block system upon the frequented sections of the roads.

Electric signals.

(3) The use of electricity in maneuvering the different signals.

Improved ballasting.

(4) The general introduction of a better and more thorough system of ballasting their roads.

The chief points of progress in locomotive construction are—

Increase in size and power of locomotives.

(1) The general use of heavier and more powerful engines than those formerly used, having 4 wheels coupled, of large diameter; designed especially for express and fast passenger trains.

Substitution of steel for iron in engines.

(2) The substitution of steel for iron in a great number of the parts of the engine.

Use of waste steam.

(3) The use of the waste steam.

Economy of fuel.

(4) The improved arrangement of the fire-grate and fire-box for the economical use of the various kinds of fuel.

Enlargement of and increase of comfort in passenger coaches.

In the construction of passenger coaches there have been important improvements in the enlargement of the space allotted to each passenger, in the provision made for the comfort of passengers upon the journey, in the furniture of the coaches, and in the mode of suspending them upon the running gear.

Sleeping-cars.

"Sleeping-cars" have been introduced upon some of the lines. A marked improvement, as yet but limited in the extent of its introduction, is to be noted in the arrangements for warming coaches of all classes. Nevertheless, the troublesome and exceedingly inefficient method of warming the cars by pans of hot water is still, strange to say, retained upon nearly all of the trains, and upon all of the lines of French railways.

Car-warming.

Substitution of steel for iron in cars.

Iron is being largely substituted for wood in the construction of freight cars and of the frames of passenger coaches.

Cross-ties.

Cross-ties.

Dimensions.

General dimensions on all roads of standard gage: Length, 9′; width, 8″; thickness, 6″. They are frequently subjected to some one of the many patent processes for preserving them from decay. Oak, beech, fir, and pine are used. The last three are the varieties subjected to the preserving process. Creosote, sulphate of copper, and bichloride of zinc are some of the preservative preparations in use—creosote and sulphate of copper by the pneumatic process, bichloride of zinc by pressure prolonged for a considerable time. At the *Galerie de la Bourdonnaye*, upon the *Champ de Mars*, there were exhibited a number of pine cross-ties which had been treated with creosote, and which had been in actual use upon the Southern Railway of France for periods ranging from eight to twenty years, and another lot which, after being treated with sulphate of copper, had been used for fifteen years; and pine telegraph poles, which, after being subjected to a like treatment, had been used from

Material.

Preservatives.

FRANCE.

twenty to twenty-five years. All of these were still in a perfect state of preservation.

Spikes.

Spikes.

Screw-spikes.

The method at present generally adopted for fastening down the rails is by the screw-spike, a hole being first bored in the wood. It is rare that the driven spike is substituted for the screw, though this is done upon the lines of the Northern and Eastern Railway Companies of France. To insure the careful screwing of the screw-spike a projecting point is provided upon the head of the spike, to act as a "tell-tale" should the workmen strike it with a hammer in order to drive it home.

Rarity of driven spikes.

Fish-joints.

Fish-joints.

Fish-joints are generally used in France, as elsewhere in Europe, whenever the shape of the rail will admit. Four bolts are used to each joint. The nuts are sometimes held in place by keys through the end of the bolt, but usually two nuts to each bolt are preferred.

Axles.

Axles.

Though these would be perhaps more appropriately considered in another connection, they will for convenience be noticed here. The French specifications, as enforced by most companies, require the axles to be of charcoal wrought iron. The pile is made of puddled blooms, and the greatest care is observed in the several processes adopted in forging the axle from these blooms. When finished each axle is subjected to a severe test. It is placed upon supports and subjected to blows of a block weighing 800 lbs. falling from a height of 15′ upon the middle of the axle; the blows to be repeated until the axle takes a set of 0.98′ between the supports, which latter are about 4.6′ apart. The axle is to be then straightened and show no cracks.

Specified requirements of axles.

Tests.

M. Villevert.

M. Villevert, the French engineer and railway constructor, in a recent essay upon the subject of cheap railways, states that the experience of France in the matter of railway development has shown that each mile of railway exploited in that country has resulted in an annual increase of the government revenues from the country traversed of $250, and in a saving in the cost of transportation of $2,500 per annum to the region through which the road is built.

Benefits conferred by construction of railways in France.

FRANCE.

The railways of France give employment to nearly 183,000 persons, including all grades of the service, or about 12.6 employés for each mile of railway in operation. As compared with England and Prussia, the number of persons in the service of the railway companies in France is as follows: In France, 12.6 per mile; in Prussia, 11.6 per mile; and in England, 12.1 per mile.

Number of railway employés in France.

Employés per mile in France, Prussia, England.

These employés are distributed among the different departments of the French railway service as follows: Administration, 2 per cent.; repair and construction of road, 30 per cent.; repair and construction of rolling stock and locomotives, 31 per cent.; movement of trains, 37 per cent.

Distribution of employés.

The mean velocity of passenger trains in France is reported as being 32 miles an hour at full speed; the velocity of the various classes of trains under full speed being as follows:

Speed of trains.

Express trains, 37 to 46 miles per hour; ordinary trains, 30 to 37 miles per hour; mixed trains, 23 to 31 miles per hour; freight trains, 11 to 15½ miles per hour.

AUSTRIA-HUNGARY.

AUSTRIA-HUNGARY.

The railway system of Austria proper embraced on the 1st of January, 1878, 6,962 miles of completed railway; that of Hungary, 4,184 miles; or 11,146 in both together, or 1 mile of railroad for every 22 miles of territorial area. The quantity of railway material needed for these lines, without reference to the wants of projected roads, is considerable; but since the general depression which has affected injuriously all branches of business in Austria-Hungary, as elsewhere, production has been limited to what was indispensable.

Extent of railways.

In the maintenance of the permanent way, supplying rails and cross-ties, the domestic product is reported to have been latterly entirely sufficient for the wants of the roads; and the Austrian and Hungarian railway companies seem to have attained a condition of independence in the matter of producing at home nearly everything needed for the building or working of their lines. The improvement in this regard has been marked in the last few years. The importation of railway material into the country was in 1872 65,000 tons; while in 1876 the exportations exceeded imports by 1,700 tons. The excellence and cheapness of the product of cross-ties from the Austrian forests have prevented any importation of material of that description.

Permanent way supplied from domestic sources.

Decrease of imports of railway material.

Exports in 1876.

The product of rails was in 1870 105,277 tons, since which time there has been some diminution; but, by reason of the

Production of rails.

AUSTRIA-HUNGARY.

introduction of Bessemer steel, the marked improvement in quality has largely compensated for the falling off in quantity. Rails are manufactured in the provinces of Lower Austria, Styria, Carinthia, Bohemia, Moravia, and Silesia.

Manufacture of rails.

Manufactories of rolling stock.

There are some large establishments in Austria for the manufacture of rolling stock, passenger and freight cars—at Vienna; Simmering; Hernal, in Lower Austria; Smichow, near Prague; and Holoubkau, in Bohemia—having an annual capacity of 6,000 cars of all kinds; but since the general prostration of business these works have largely curtailed their operations.

Increased activity and exports.

These establishments have built up a considerable foreign market for their products since the decline of the home demand, and the importation of railway rolling material into Austria has almost wholly ceased. In 1875 the exports were 2,373 cars, and in 1876 1,100 cars; in 1872 the imports were 3,154 cars, and in 1876 48 cars!

Locomotive manufactories in 1875.

The manufacture of locomotives is chiefly concentrated at Vienna. In 1875 there were 5 manufactories in Austria, which turned out 214 locomotives and 191 tenders. In 1876

Production in 1876.

only 3 of these continued in operation, and they produced only 59 locomotives and 26 tenders. The rolling stock of

Rolling stock of Austrian railways in 1877.

Austrian railways of standard gage in 1877 comprised 2,322 locomotives, 2,118 tenders, 275 snow-plows, 5,113 passenger cars, and 54,901 freight and other cars.

GREAT BRITAIN.

GREAT BRITAIN.

Great progress and improvement of late years.

The progress in railway construction in Great Britain during the past ten years has been very marked; and the improvement in the character of the permanent way, as well as in rolling material and locomotives, has been very important and very valuable. The advance in the mode and manner of construction, and in the character of materials used, has perhaps kept pace with the increase in the number of miles of completed roads, the capital invested in this business, and the vast increase in the business transacted by the railroads of the United Kingdom. These have been very large, as will appear from the following tabulated statement, taken from the reports of the Board of Trade, and giving, at intervals from 1854 to 1877, a view of the extent and character of the operations of the railway system of Great Britain and Ireland.

GREAT BRITAIN.

Table of miles of railway, capital, number of passengers, receipts, expenses.

Table showing the number of miles, capital invested, and receipts on the railways of the United Kingdom, 1854–1877.

Year.	Length in miles of lines open for traffic at end of each year.			Capital paid up, including loans, etc.	Capital paid up per mile of line open.	Number of passengers carried, exclusive of season tickets.	Gross receipts for year.			Total receipts for year from all sources, including rents.	Gross receipts per train mile.	Working expenses.	Ratio of expenses to gross receipts.	Net receipts.	Ratio of net earnings to gross receipts.
	Double or more.	Single.	Total length.				From passengers.	Percentage of receipts from passengers to totals.	From freights.						
1854	6,103	1,950	8,053	£286,068,794	£35,523	111,180,165	£10,244,904	.51	£9,970,770	£20,215,724	£1 35	Not given	*Per ct.*	Not given	
1857	6,357	2,682	9,039	315,167,258	34,866	138,971,240	11,888,219	.49	12,296,392	24,174,611	1 41	Not given		Not given	
1862	7,009	4,542	11,551	385,218,482	33,349	180,429,071	13,911,965	.48	15,216,673	29,128,558	1 33	£14,968,409	.49	£14,160,149	3.86
1867	7,844	6,403	14,247	502,262,357	35,254	287,638,113	17,935,634	.45	21,544,365	39,479,999	1 30	19,846,952	.50	19,632,047	3.91
1872	8,513	7,302	15,814	569,047,846	35,964	422,874,822	22,287,555	.42	29,016,559	51,305,510	1 32	25,277,640	.49	25,967,870	4.74
1877	9,295	7,842	17,077	674,059,048	39,472	551,568,654	26,694,110	.42	34,109,947	62,978,228	1 35	33,857,978	.54	29,115,250	4.32

GREAT BRITAIN.

Average cost per mile.

Ratio of net earnings to capital invested.

At the end of 1871 the total average cost of all the railways of the United Kingdom was $174,000 per mile. In view of the enormous sums of money expended in the construction of the railroads of Great Britain and Ireland, the fact that their net earnings for the past eighteen years have yielded more than 4.26 per centum per annum upon the whole amount of capital invested, gives some idea of the immensity of their traffic, and of the prudence, economy, skill, and faithfulness of the management which combine to produce such results.

Law expenses in obtaining corporate rights.

Right of way.

One of the larger items in the cost of British railroads has been the expense incurred in obtaining from Parliament acts of incorporation, with authority to condemn land for the necessary purposes of the companies. The "right of way" has also been a much larger element of first cost than in any other country.

Durable character of the work.

But the durable and thorough manner in which the English roads are built, the superior character of the superstructure and the equipment, rendered a very large outlay necessary.

Velocity of trains.

The velocity at which passenger trains are run is greater upon the English roads than in any other country in the world. The mean speed of passenger trains is reported at 40 miles an hour when running at full speed. The velocity of fast and express trains is much greater, in some cases attaining a maximum speed of 70 miles an hour.

Railway exhibits at Paris.

RAILWAY EXHIBITS AT PARIS.

With this glance at the railway systems of the countries of Europe which have been selected as fairly representative of European railway progress, I will now briefly review those exhibits in the more important classes of railway material and rolling stock which appeared to most fairly illustrate the best practice and the most advanced types of machinery and methods of construction prevailing in the principal countries of Europe represented at the Exposition.

Divisions of the subject.

In the treatment of the subject the following general order will be observed:

(1) *Locomotives;*
(2) *Railway rolling stock;*
(3) *Narrow-gage railways, tramways, and cars;* and
(4) *Systems of brakes and signaling apparatus.*

Completeness of the French exhibit.

The representation of French locomotives, rolling stock, and railway material at the Paris Exposition was, as was to have been expected, much fuller and more complete than

that of any other country, and afforded a fair opportunity for studying the appliances and modes of construction adopted by the French railway companies. It may be stated generally, and without qualification, that the collection of railway exhibits contributed by the railway companies and manufacturers of that country gave evidence of a very high degree of skill and excellence on the part of the engineers and artisans of the French nation. *Railway exhibits at Paris.* Excellence of the French exhibits.

It is proper here to remark, however, that the difficulty experienced in some quarters in obtaining particulars and data necessary to a thorough understanding of some of the most interesting machines and appliances among the railway exhibits in the French section was found very embarrassing in the prosecution of the work to which the writer was assigned. The channels of trustworthy information in regard to many of these exhibits seemed to be guarded with a singular jealousy; and while there was no lack of courtesy on the part of the officials and agents in charge, there was sometimes a reserve and apparent reluctance in communicating special information desired, which rendered impracticable a full and just criticism of certain interesting exhibits. There were a number of marked exceptions to this, and among them I desire to acknowledge kind attention and full responses to inquiries from the officers in charge of the splendid collection of exhibits of the Western Railway Company of France, and particularly from M. Delaistre, director, and M. E. Mayer, engineer-in-chief of the rolling-stock department of that company, and to M. Marlier, secretary of the executive committee of the "International Congress for the Amelioration of the Means of Transport." Acknowledgments: M. Delaistre. M. E. Mayer. M. A. Marlier.

FRENCH LOCOMOTIVES.

Locomotives. FRANCE.

The French section contained far the largest number and the greatest variety of railway machines, apparatus, and fixtures, and these were probably fair exponents of the best practice of that country. The locomotives exhibited by the French railway companies and manufacturers were about half of the whole number exhibited at Paris. They were many of them machines which had been in the actual service of the French roads, and nearly all represented types in ordinary use upon those lines. All were remarkable for the wonderful perfection and finish of the workmanship and the excellence of the materials used in their construction. Half the exhibits French. Remarkable excellence.

Among the most admirable of these exhibits were those

FRANCE.

Exhibit of locomotives.

Locomotives of the Western Railway Co.

Plate I.

presented by the Western Railway Company of France. I noticed, among others, a very fine locomotive and tender, with 8 wheels, of which 4 were coupled. Its machinery is so arranged that it may be propelled indifferently either backward or forward. The general plan of the machine is indicated in Plate I. The locomotive is reversed by a screw-brake, worked by the waste steam. The regulator is upon the outside of the dome, at the outlet of the steam-pipe.

The packing of the piston-rods, the cylinders, and the regulator is metallic, and of the system "Duterne." The boilers are supplied by the aid of two suction-injectors of the system "Turck."

Description.

The bunkers for coal and the tanks for water are about equal in capacity to those of an ordinary tender, the latter holding, when full, 1,430 gallons of water. The locomotive has been so constructed that the load is very uniformly distributed over the several axles, that upon the leading and trailing axles being nearly equal, as are also the loads upon each of the two coupled axles, when the tanks and bunkers are full, half full, or one-third full.

The following table indicates the distribution of the load in the three cases:

Distribution of weights, in pounds.

Distribution of the load.

	Leading axles.	Driving axle.	Bearing axle.	Trailing axle.	Totals.
Tanks, etc., fully charged	21,600	27,150	27,150	22,000	97,900
Tanks, etc., half full	19,175	24,950	24,840	19,225	88,790
Tanks, etc., one-third full	19,050	24,250	24,050	18,350	85,700

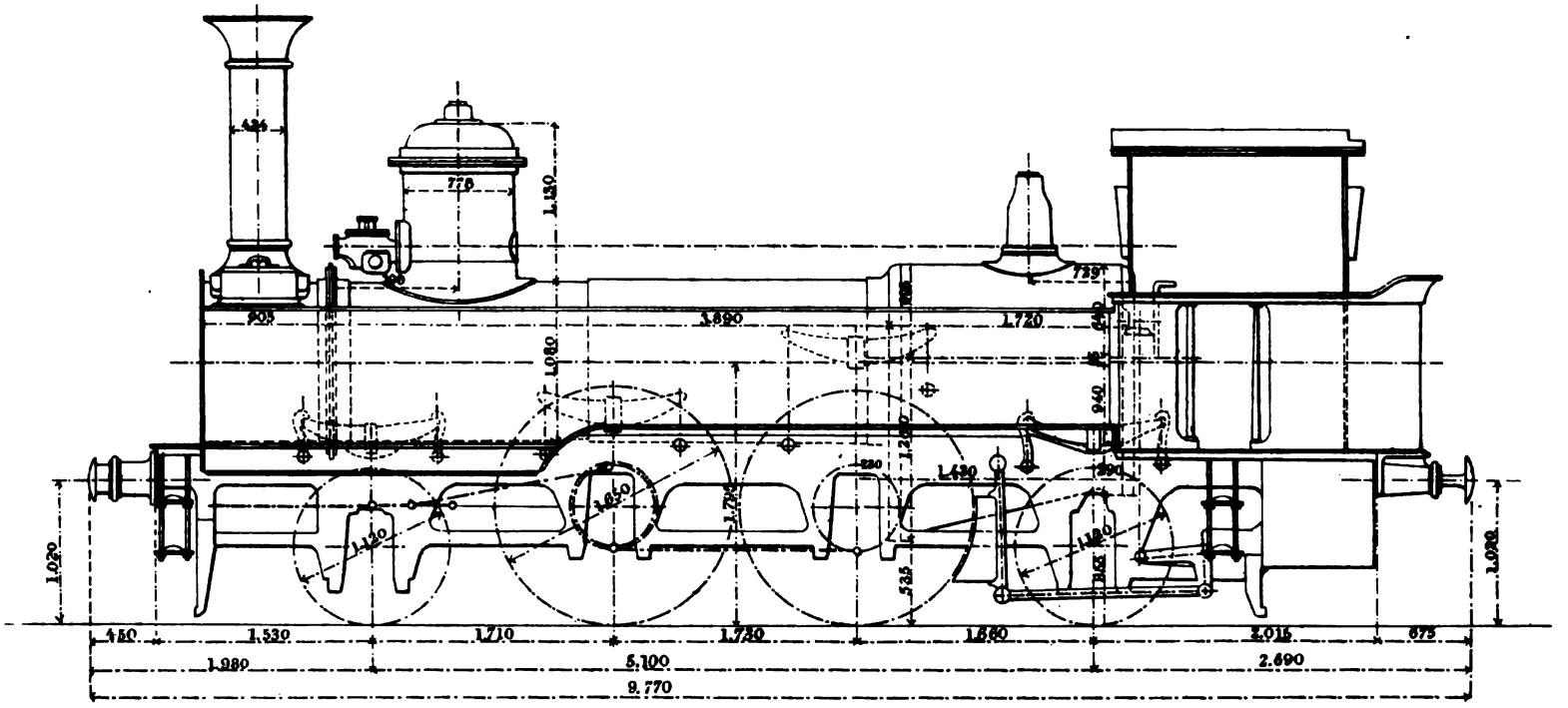
Dimensions.

The following are the principal dimensions of this locomotive, given in meters:

Table of dimensions and other particulars.

Diameter of cylinders		0.420 meter.
Stroke of pistons		0.560 meter.
Exterior length of fire-box		1.720 meters.
Exterior breadth of fire-box		1.120 meters.
Interior length of fire-box	above	1.420 meters.
	below	1.470 meters.
Interior breadth of fire-box		0.932 meter.
Height of fire-box above grate	behind	1.000 meters.
	in front	1.150 meters.
Length of tubes between the plates		4.000 meters.
Number of tubes		149
Interior diameter of tubes		0.045 meter.
Heating surface	of fire-box	6.040 sq. meters.
	of tubes	93.620 sq. meters.

Plate No. 1.



LOCOMOTIVE AND TENDER

EXHIBITED BY

THE WESTERN RAILWAY COMPANY OF FRANCE.

FRANCE.

Total heating surface	99.660 sq. meters.
Surface of fire-grate	1.370 sq. meters.
Volume of water in boiler	2.450 cu. meters.
Volume of steam in boiler	1.550 cu. meters.
Charge of fuel (weight in furnace)	440 lbs.
Volume of water in tanks	6.500 cu. meters.
Weight of fuel in bunkers	3,000 lbs.
Weight of locomotive empty	72,860 lbs.
Weight of locomotive in complete working order	97,900 lbs.
Wheel base	5.100 meters.

Description of locomotive of Western Railway Co. Plate 1.

Express engine.

The Western Railway Company exhibited other very creditable specimens of their locomotive products, among them a beautiful express engine built for this company by the *Société des Batignolles*. This locomotive is the latest development of a type introduced about 1855, when the demand for locomotives of two axles, coupled, and wheels of large diameter, with interior cylinders and exterior distribution, for moving express trains, came to be considered imperative. These engines possess the maximum traction power as yet attained by the Western Railway Company with locomotives of two axles, coupled, and a tender of 12 tons.

Plate 2.

Type of 1855.

Dimensions.

The annexed illustration, Plate 2, presents an outline view of this locomotive. The dimensions of its principal parts are given below:

Length of fire-grate	1.624 meters.
Breadth of fire-grate	1.078 meters.
Surface of fire-grate	1.750 sq. meters.
Height of fire-box above grate in front	1.170 meters.
Height of fire-box above grate behind	1.020 meters.
Capacity of fire-box	1.880 cu. meters.
Length of tubes between plates	3.850 meters.
Interior diameter of tubes	0.045 meter.
Number of tubes	156
Heating surface of tubes	94.750 sq. meters.
Heating surface of fire-box	7.100 sq. meters.
Total heating surface	101.450 sq. meters.
Mean diameter of boiler	1.170 sq. meters.
Thickness of plate	0.014 sq. meter.
Capacity of boiler with water 0.10 meters above top of fire-box	2.800 cu. meters.
Interior length of smoke-box along boiler axis	0.700 meter.
Interior measurement of smoke-box across axis of boiler	1.148 meters.
Interior diameter of chimney	0.420 meter.
Diameter of cylinders	0.420 meter.
Stroke of pistons	0.600 meter.
Number of axles	3
Wheel-base	4.400 meters.
Diameter of driving and bearing wheels	1.930 meters.
Diameter of leading wheels	1.290 meters.

FRANCE.

Express engine of Western Railway Co. Plate 2.

Weight of locomotive upon the rails and distribution of burden	leading axle	11 tons 100 lbs.
	driving axle	12 tons 500 lbs.
	bearing axle	12 tons 500 lbs.
Weight of locomotive in working order		36 tons 100 lbs.
Weight of locomotive empty		33 tons.
Adhesion		4 tons 220 lbs.

Description.

The tender used in connection with this locomotive is also represented in the diagrams at the foot of Plate 2. The frame of the tender is entirely of iron, the tanks and bunkers resting upon a wooden floor. The buffers are arranged so as to facilitate the passage of curves, to diminish the oscillation of the train, and to diminish the concussion. There are two inner buffers, and two others acting in the ordinary way. The couplings between the engines and tender and the tender and train are strong, and arranged so as to unify the movement of the locomotive, tender, and train.

Tender.

Particulars as to tender.

Weight of water in tanks		6 tons 660 lbs.
Weight of fuel in bunkers		3 tons 1,100 lbs.
Number of axles		2 tons
Wheel base		2.800 meters.
Diameter of wheels		1.120 meters.
Weight upon rails of tender, loaded, and its distribution by axles	forward axle	11 tons 550 lbs.
	rear axle	11 tons 550 lbs.
Total weight of tender loaded		22 tons 1,100 lbs.
Total weight of tender empty		11 tons 1,550 lbs.

Schneider & Co.

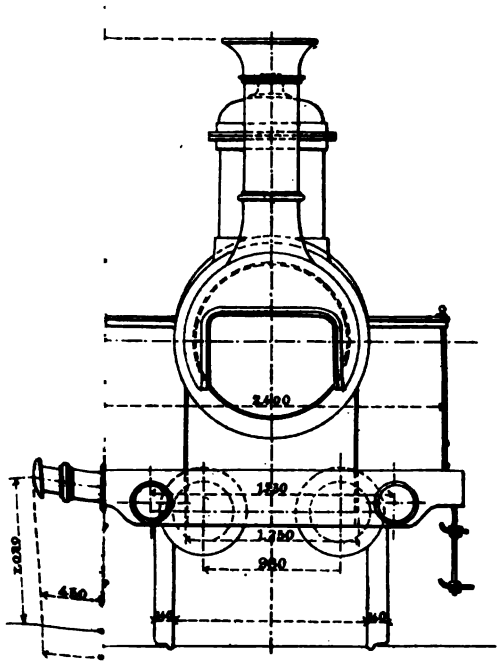
The most interesting and remarkable collection of iron and steel manufactures to be seen at Paris, or probably ever exhibited before at any place in the world, was that of MM. Schneider & Co., of Creuzot, at their large pavilion upon the *Champ de Mars*. Although their enormous works—one of the largest establishments of the kind in the world—produce almost every description of iron and steel fabrics used by civilized man, and manufacture a number of varieties of locomotives and railway machinery, there was only one locomotive in their collections of exhibits. This was a powerful and well-finished engine and tender, made for passenger and mixed trains, and in its finish and in its construction well worthy of the splendid reputation of its makers.

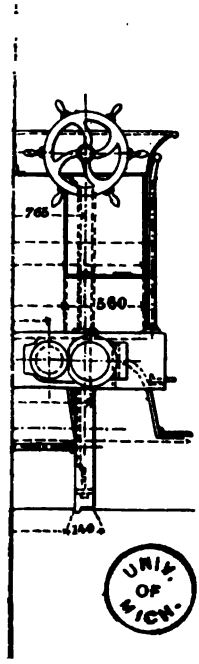
Locomotive for passenger and mixed trains.

Description.

The engine had four coupled wheels and two leading wheels. The piston-rods, side-rods, axles, tires, slide-bars, and motive-pieces were made of steel. Its fire-grate was quite large, and admitted of the use of fuel of inferior quality. It was designed to be run at a speed of 30 miles an hour.

Plate No. 2.





UNIV. OF MICH.

Principal dimensions and weights; Creuzot locomotive. FRANCE.

Schneider & Co.'s locomotive

Weight in working order	79,000 lbs.
Weight empty	61,500 lbs.
Surface of grate	1.75 sq. meters.
Heating surface of fire-box	7.400 sq. meters.
Heating surface of tubes	82.000 sq. meters.
Total heating surface	89.400 sq. meters.
Diameter of cylinders	0.400 meter.
Stroke of pistons	0.600 meter.
Diameter of coupled wheels	1.610 meters.
Diameter of leading wheels	1.210 meters.

Dimensions.

Locomotives of the Paris, Lyons, and Mediterranean Railway Co.

The three locomotives exhibited by the Paris, Lyons, and Mediterranean Railway Company were all remarkable for faithful and finished workmanship and the skill displayed in their construction. Like nearly all the locomotives exhibited in the French section they were taken from the actual service of the company, and represented types of which there are a number of each kind now in daily use. The business of this line—the artery connecting Paris with the Mediterranean and Italy—and particularly its passenger traffic, has increased so rapidly that the company has found it necessary largely to increase the tractive capacity of its locomotives, and in the past few years the company has built a number of machines of great power and designed to be run at a high rate of speed.

Progress in class of powerful engines.

Passenger engine. Plate 3.

One of the locomotives mentioned above, a powerful passenger engine, exemplified the latest practice of this important company, and may be selected as an excellent example of a type of heavy passenger locomotive, adapted to either way, fast, or express trains, highly appreciated upon the Continent.

Plate from London "Engineering."

This engine has been recently fully described in the pages of the London "Engineering," and the illustration given of it in Plate 3 and most of the particulars here mentioned in regard to it are used by the courtesy of Mr. William H. Maw, one of the editors of that valuable periodical.

William H. Maw.

Description of the engine. Plate 3.

This locomotive was made at the shops of the company in 1877–'78, and is one of 60 of the same type built in the last few years. As will be seen from the illustration, it has 8 wheels, of which 4 are coupled; the boiler is of unusual length, and all of the axles are under it, except the trailing axle, which is under the fire-box; the cylinders are exterior and of large capacity. The working power of the engine

FRANCE.

under the different conditions stated is shown by the following table:

Passenger engine of the Paris, Lyons, and Mediterranean Railway Co. Plate 3.

Power and speed with different classes of trains.

Character of train.	Speed per hour.	Weight of train, exclusive of engine and tender, drawn on the gradients given.				
		Level.	1 in 400.	1 in 200.	1 in 100.	1 in 60.
	Miles.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Way	31	388	257	187	109	67
Fast	37½	277	189	137	78	45
Express	44	208	145	105	57	30

Description.

The leading and trailing axles have each a separate spring for each axle-box; the bearings of all the axles are inside, except the trailing axle, the bearings of which are outside. The pistons and piston-rods are of wrought iron, and have their stuffing-boxes fitted with metallic packing, according to the system known as "Duterne's."

The engine is reversed by a screw, and is fitted with Le Chatelier's counter-pressure apparatus, pipes for admitting a mixture of steam and water into the exhaust-pipes when the engine is reversed. It is also furnished with a sand-box, provided with sand-valves worked from the foot-plate. The horizontal stays between the sides of the casing above the fire-box crown are of steel. The grate-bars are of wrought iron, steeply inclined, except in front, where there is a short movable section worked by a gearing so arranged that it can be lowered if desired.

There is a horizontal screen arranged in the smoke-box just above the level of the tubes so as to stop the passage of cinders and sparks. The chimney is cylindrical and has a damper at the top. The blast-nozzle is variable and is placed rather high.

The brake is applied by a Delpech double screw, designed to give a rapid movement to the blocks until they are nearly in contact with the wheels, and a very powerful pressure afterwards. The brake-blocks are of wood.

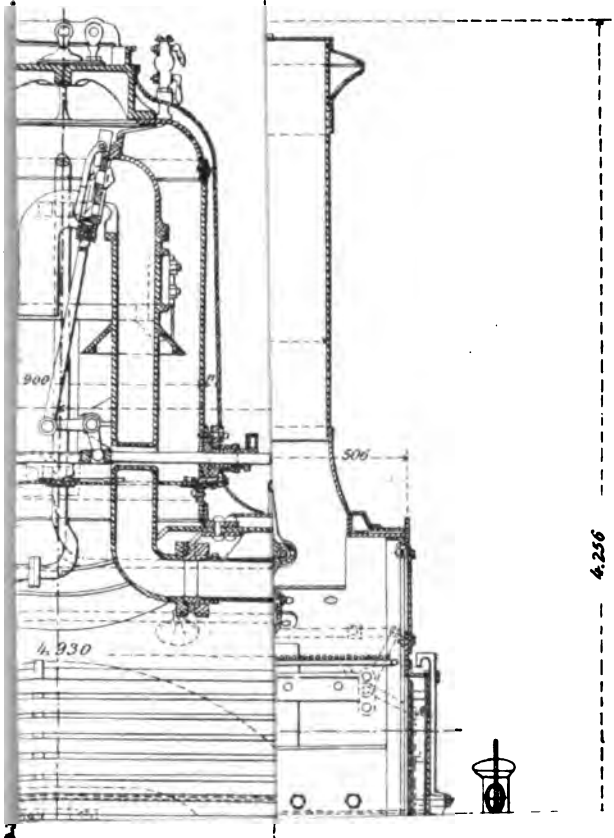
Dimensions and other particulars.

Dimensions.

Diameter of cylinders	19.70 in.
Stroke of pistons	2 ft. 1.60 in.
Diameter of coupled wheels	6 ft. 10.70 in.
Diameter of leading and trailing wheels	4 ft. 3.20 in.
Wheel base of engine	18 ft. 4.30 in.
Mean diameter of boiler	4 ft. 6.75 in.
Thickness of boiler-plate	0.57 in.
Number of tubes	164
Length between tube-plates	16 ft. 2.20 in.

RANEAN RA

. MARIE, ENGINEER-IN-



Inside diameter of tubes	1. 81 in.	FRANCE.
Outside diameter of tubes	2. 00 in.	
Length of fire-grate	6 ft. 11. 30 in.	Passenger engine of Paris, Lyons, and Mediterranean Railway Co. Plate 3.
Width of fire-grate	3 ft. 3. 80 in.	
Height of fire-box crown { in front	4 ft. 7. 80 in.	
Height of fire-box crown { at back	2 ft. 10. 60 in.	
Volume of fire-box	86. 5 cu. ft.	
Inside diameter of smoke-stack	1 ft. 7. 70 in.	
Fire-grate surface	23. 00 sq. ft.	
Heating surface { fire-box	96. 90 sq. ft.	
Heating surface { tubes (exterior)	1, 390. 00 sq. ft.	
Total heating surface, including exterior tube surface	1, 486. 90 sq. ft.	
Sectional area through tubes	2. 93 sq. ft.	
Sectional area of smoke-stack	2. 12 sq. ft.	Dimensions.
Ratio of fire-grate area to heating surface	1 : 64. 67	
Ratio of sectional area through tubes to fire-grate area	1 : 7. 86	
Ratio of sectional area of chimney to fire-grate area	1 : 10. 85	
Number of internal diameters in length of tubes	107. 30	
Working pressure per square inch	128 lbs.	
Weight of locomotive empty	40 tons 400 lbs.	
Weight of locomotive in working order	43 tons 1, 900 lbs.	
Weight of fuel carried by tender	4 tons.	
Water carried by tender	2, 244 gals.	

AUSTRIA-HUNGARY.

LOCOMOTIVES OF AUSTRIA-HUNGARY.

Locomotives.

There were 4 locomotives exhibited in the section of Austria-Hungary—one was a small tank-locomotive for service in the mines; the others representatives of the best types adopted by the Austrian and Hungarian railway companies. All were admirably constructed, and both in design and execution exhibited a degree of skill which entitles their makers to rank among the manufacturers of the best railway material produced upon the Continent. The collection of exhibits of the Austrian State Railway Company was one of the most interesting and instructive to be seen at Paris. Their exhibits comprised designs and models of the various descriptions of railway machinery, fixtures, and appliances actually employed in the service of the company, presenting in an attractive form a full and satisfactory view of Austrian railway locomotive practice.

Superior construction.

Exhibits fully illustrating the Austrian railway practice.

The special characteristic of the locomotives manufactured by the Austrian State Railway Company is the excellent arrangement of the fire-box and fire-grate for the purpose of permitting the use of a small and inferior article of fuel supplied by the coal mines of Kladno, near Prague, and Rossnitz, near Vienna. These coals are very inferior in their flame-producing properties, and contain a large percentage of incombustible constituents. In order to produce better results they are mixed with small coal from the Stey-

Austrian State Railway Co.

Special arrangements to suit inferior fuel.

AUSTRIA-HUNGARY.

erdorf mines, the latter and the coals from Kladno being usually mixed with a small percentage of lump coal. The small coals from Kladno are very indifferent in quality, give a short flame, coke with difficulty, and contain a little sulphur and 20 per cent. of cinders and stone. The Rossnitz mixed coals coke badly, are very sulphurous, make a coke of bad quality, and contain 20 to 25 per cent. of ashes. Employed alone, they work badly, but mixed with the slack coal from the Kladno mines each seems, to some extent, to correct the defects of the other. The Steyerdorf coals are of excellent quality, resembling the English semi-bituminous, give a good flame, make excellent coke, are only very slightly sulphurous, and contain only from 8 to 10 per cent. of ashes. Their intermixture with the two inferior coals from Kladno and Rossnitz add greatly to their heat-producing capacity.

Locomotives of Austrian State Railway Co.

Peculiarity of the fuel employed.

Adaptation of the fire-box and grate to the kind of fuel.

The introduction of the new types of locomotive now in the service of the Austrian Railway Company has rendered the use of this fuel practicable, and effected a considerable reduction in this item of railway-operating expenses. Since the introduction of this system the consumption of lump and large coals upon these lines of railway has been reduced from 22,200 tons in 1872 to 70 tons in 1876.

Success.

The use of these small coals by the Austrian Railway Company has never occasioned any practical difficulty, either in respect to speed of trains, regularity of train movement, or working capacity of the locomotives.

Possible need for the use of our slack and small coals in locomotives.

The abundance and cheapness of fuel in almost all parts of the United States have not as yet rendered it necessary that our railway companies should resort to devices and methods for the use of the slack and small coals of the mines as fuel for locomotives; but there are large sections of the country where the question of cheap fuel is already one of vital interest, and it is one of more or less importance and of growing interest everywhere.

Classes of locomotives used by the Austrian State Railway Co.

The Austrian State Railway Company employs three descriptions of locomotives constructed with reference to the use of slack and small coals:

(1) Freight locomotives, having 8 coupled wheels, of which there are 30 in use and 10 in process of construction.

(2) Locomotives designed for service at stations, having 6 wheels, all coupled; of these there are already 17 in the employment of the company.

(3) Locomotives designed for either passenger or freight service or for mixed trains.

AUSTRIA-HUNGARY.

This last-mentioned type has been selected for a fuller description as a fair exponent of the system. An illustration of it is given in Plate 4.

Passenger and mixed-train locomotive of the Austrian State Railway Co. Plate 4.

The fire-grate, as in the two other descriptions of locomotives mentioned, is made very large, in order that the depth of fuel upon it may not be considerable. They are supplied with the Le Chatelier apparatus for reversing the engine, by letting into the cylinders steam and water in small quantities from the exhaust-pipes, the pipes being so arranged as to prevent dust and hurtful gases from being drawn in from the smoke-box.

Description

The boilers are of Martin steel; the tube-plate of the smoke-box is of copper; the connecting and coupling rods are of steel, grooved in a fashion to reduce their weight as far as practicable. The following table exhibits the average consumption of small coal upon these locomotives:

Consumption of coal.

	Quantity of coal from Kladno.	Quantity of coal from Steyerdorf.
	Pounds.	*Pounds.*
Coal consumed for each train mile	58	59
Coal consumed for each one hundred tons moved one mile	16	14
	Cents.	*Cents.*
Cost of coal consumed per train mile	8.29	11.05
Cost of coal for each one hundred tons drawn one mile	2.46	2.60

Dimensions and particulars.

Dimensions.

Length of fire-grate	1.300 meters.
Breadth of fire-grate	1.050 meters.
Surface of fire-grate	1.890 sq. meters.
Length of fire-box { at top	1.770 meters.
Length of fire-box { at bottom	1.800 meters.
Breadth of fire-box { at top	1.090 meters.
Breadth of fire-box { at bottom	1.050 meters.
Height of fire-box	1.536 meters.
Heating surface of fire-box	9.100 sq. meters.
Heating surface of tubes	129.600 sq. meters.
Total heating surface	138.700 sq. meters.
Smoke-stack, interior diameter	0.440 meter.
Diameter of driving wheels	1.450 meters.
Diameter of coupled wheels	1.450 meters.
Diameter of body of wheels within tires	1.340 meters.
Weight of driving wheels	5,210 lbs.
Weight of each pair of coupled wheels	4,295 lbs.
Diameter of driving axles at center	0.158 meter.
Diameter of coupled axles at center	0.158 meter.
Diameter of spindle	0.165 meter.

AUSTRIA-HUNGARY.

Passenger and mixed-train locomotive of Austrian State Railway Co. Plate 4.

	Springs:	
	Distance between points of suspension	0.970 meter.
	Breadth of plates	0.900 meter.
	Thickness	0.100 meter.
	Number to each spring	17
	Mechanism:	
	Diameter of cylinders	0.450 meter.
	Stroke of piston	0.650 meter.
	Length of connecting-rods	1.900 meters.
	Greatest breadth of locomotive	2.790 meters.
	Boiler:	
Dimensions.	Length of boiler	4.620 meters.
	Exterior diameter	1.300 meters.
	Number of tubes	175
	Exterior diameter of tubes	0.052 meter.
	Length between tube-plates	4.550 meters.
	Volume of steam, with water-line 105^{mm} above top of fire box	1.610 cu. meters.

Distribution of weight.

Distribution of weight.

	Empty.	In working order.
	Tons.	*Tons.*
On leading wheels	10.97	12.75
On driving wheels	11.37	12.70
On trailing wheels	11.86	12.75
Total	34.20	38.20

Average load.

The average load hauled during the year 1877 by these locomotives was 340 tons. The company already has 20 machines of this type, and they are represented to have done excellent service.

Fire-boxes.

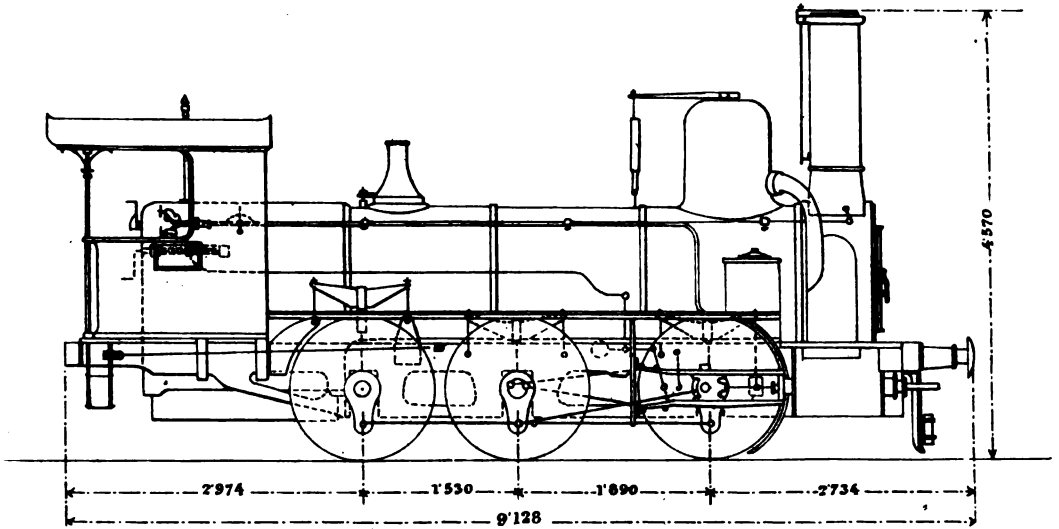
The fire-boxes in use upon the locomotives of this company are of copper, though experimental tests are now being made of fire-boxes made of a very soft Martin steel. The stays found to give the best results are those made of copper. Iron or steel stays have not been found very desirable. The copper used is required to have a resistance of 24 kilograms for each square millimeter, or 34.135 lbs. per square inch, and an extension capacity of 20 per cent. before fracture.

Boilers.

The company has 215 boilers of Bessemer, Martin, or cast steel. Experience upon the Austrian roads shows that they corrode very rapidly, the corrosion being doubtless greatly accelerated by reason of the inferior character of the fuel used. The corrosion of steel and iron boilers is believed to be about the same. Upon this line the vital parts of the boilers have to be replaced after every three or four years of active service. The past experience of the Austrian State Company has shown that the best material for the manufacture of boilers is a soft homogeneous steel not liable to harden readily. Such a metal is believed to have been obtained in

Type 1877. Plate No. 4.

LOCOMOTIVE OF THE AUSTRIAN STATE RAILWAY CO.



AUSTRIA-HUNGARY.

a steel now being made by the Martin process at the company's works at Reschicza.

Passenger and mixed-train locomotive of Austrian State Railway Co. Plate 4.

The experimental tests made by Professor Jenny, of the Polytechnic School of Vienna, with the boiler-plates manufactured for this company at their works at Simmering, show that the metal of which they are made is sufficiently soft to remove any apprehension as to their liability to sudden rupture.

Description.

The boiler-tubes of the company's engines are of brass, the composition of which is 30 parts zinc and 70 parts copper. They are all of the same diameter—interior, 0.048; exterior, 0.052.

Composition of bronzes.

The following compositions, designated as bronzes, are used for the several purposes mentioned:

(1) For locomotive bearings, slide-valves, valves, etc., 84 parts of copper and 16 parts of tin.

(2) For coach and car bearings, 85 parts of copper and 15 of tin.

(3) For the various cocks, etc., 90 parts of copper and 10 of tin.

Passenger and mixed-train locomotive of the Theiss Railway of Hungary. Plate 5.

One of the most admirable machines exhibited at Paris was the powerful locomotive built at the works of the Hungarian State Railways at Buda-Pest for the Theiss Railway. In simplicity of construction it approached more nearly to the best types of American and English locomotives than the locomotives built by the European Continental railway companies generally do. It represents a design entirely new and but recently adopted by the Theiss Railway Company. It is built for the purpose of hauling passenger and mixed trains at a high speed. It has an actual tractive power upon a gradient of 1 in 800, as follows: 750 tons at a speed of 15 miles, 500 tons at a speed of 22 miles, and 300 tons at a speed of 37 miles per hour.

New design.

Tractive power.

Plate 5 gives a fair illustration of this superb machine.

Description of Plate 5.

There are no curves of short radii upon the Theiss Railway, and accordingly it was not found necessary to allow any lateral play to the axles of this locomotive, though its wheel-base is 11′ 8″.

As will be seen from the engraving, this machine has 6 wheels, all coupled, and its cylinders are exterior. It is designed with reference to the use of wood as its fuel, and is provided with Klein's spark-arrester. Two injectors of Friedman's system supply the boiler, one of 7 and the other of 9 millimeters. The dome is larger than usual and contains the regulator.

AUSTRIA-HUNGARY.

Locomotive of Theiss Railway of Hungary.

The arrangements for the distribution of steam are after the system of Mr. Stevenson, except that in place of the valve in ordinary use there is a spiral spring which serves to equalize the weights of the valve-slides and appurtenances. The piston-rods pass entirely through the forward heads of the cylinders, as indicated, an excellent arrangement for supporting the piston and securing smoothness of action. The springs are adjusted below the axle-boxes, and those of the driving and trailing axles are coupled by compensating beams.

Description.

Equipoised valves.

It is claimed that this locomotive has the merit of establishing the feasibility and advantage of applying perfectly equipoised valves to locomotives, an arrangement so often attempted without success. The tires, axles, springs, connecting and coupling rods, valve-spindles, piston-rods, and motion-bars are of cast steel; the wheels and axle-boxes are of wrought iron; the valve-gearing of refined wrought iron. All the joints are case-hardened.

The materials the product of Hungary.

Almost all of the materials used in the construction of the machine are the products of Hungarian factories. The plates of the boiler-frames, the boiler-plates, and the refined iron used in the construction of other parts of the locomotive are from the Royal Hungarian Iron Works of Brazowa; the copper from the copper works of Upper Hungary; and nearly all the steel used from the works of the Austrian State Railway Company at Reschicza. The cost of this locomotive delivered in the station at Buda-Pest is $10,700.

Dimensions of locomotive and particulars.

Dimensions.

Diameter of cylinders		0.420 meter.
Stroke of pistons		0.630 meter.
Diameter of driving wheels		1.617 meters.
Wheel base		3.650 meters.
Diameter of barrel of boiler		1.328 meters.
Fire-grate	length	1.930 meters.
	breadth	1.020 meters.
	surface	1.970 sq. meters.
Fire-box	interior length	1.900 meters.
	interior breadth	1.100, 1.120 meters.
	interior height	1,130, 1.470 meters.
	interior heating surface	9.000 sq. meters.
Tubes	number	166
	length between plates	3.500 meters.
	exterior diameter	0.052 meter.
	heating surface	95.000 sq. meters.
Total heating surface of machine		104.000 sq. meters.
Weight of locomotive empty		30 tons.
Weight of locomotive ready for work		34 tons.

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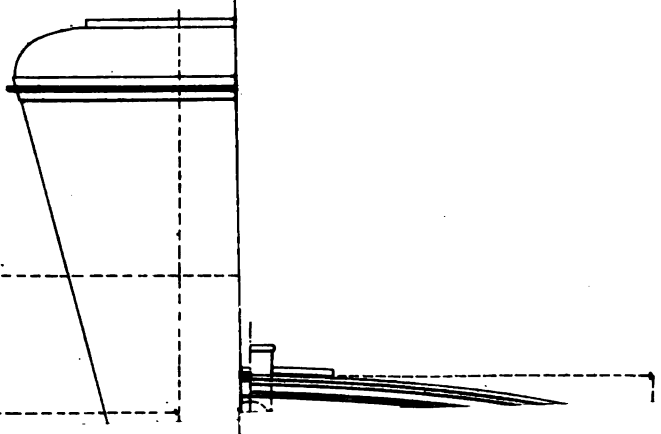
Plate No. 5.



Locomotives.

The locomotives exhibited in the British section were, as may be said of the machinery exhibits of the United Kingdom generally, remarkable for the skill, the directness, the strong common sense, and the faithfulness illustrated in their construction.

Locomotive of Sharp, Stewart & Co.

A splendid proof of the practical mechanical skill and high attainments in mechanical engineering of the English was furnished by the locomotive manufactured by Messrs. Sharp, Stewart, & Co., of Manchester, a machine of such excellent design and workmanship that it well deserves to be chosen as illustrative of the best locomotive practice of the British railways. The agent in charge of the very creditable collection of exhibits of Messrs. Sharp, Stewart, & Co. was kind enough to refer the writer to an exhaustive description of this machine, which was prepared for and appeared in "Engineering," for full particulars, and I am indebted to that paper for the details now given and the illustration of the machine on Plate 6.

Plate 6 from London "Engineering."

Description.

This engine is designed for express passenger service, and, as shown in the engraving, has inside cylinders, 2 driving and 2 trailing wheels, all coupled. It combines in its construction the practice of Messrs. Sharp, Stewart, & Co. and that adopted by the Northwestern Railway Company of England, in its design embracing the most approved features of English railway locomotive engineering. "The cylinders are 18″ in diameter, the coupled wheels are 6′ 6″ in diameter, and the tractive force is calculated, therefore, to be 103.8 lbs. for each pound of effective pressure per square inch on the pistons." The leading wheels are 4′ in diameter. The cylinders are placed close together, and thus the driving-axles admit of very long bearings; and, to allow this, the valve-faces have been placed above the cylinders and inclined both laterally and longitudinally. The piston-rods, connecting and coupling rods are all of Bessemer steel. The pistons are filled with gun-metal packing-rings. There are only two guiding-bars to each cylinder, and those are supported by the motion-plate at some distance from their rear ends, the arrangement being such that the cross-heads can be drawn out without taking down the bars. The slide-bars are of case-hardened wrought iron. The link-motion is of the kind known as the "Allan straight-link" type, and all thoroughly case hardened.

Details and dimensions.

The engine is reversed by a screw with hand-wheel fixed

GREAT BRITAIN.

Locomotive of Sharp, Stewart & Co. Plate 6.

on one of the hind splashes. The coupling is very simply effected by rods with solid ends with bushes forced in. Axle and crank pins are all of Bessemer steel, as also are the axles.

The bearings of the axles of the driving and trailing wheels are 9″ long and 7½″ in diameter, and those of the leading axle are 10″ long, with a diameter of 6¼″.

Description and dimensions.

"The driving and trailing axle-boxes are of case-hardened cast iron, working in guides of cast steel not fitted with wedges. The leading axle-boxes are of cast iron, working in cast-iron guides, there being a lateral play of ½″ allowed in each direction between the flanges of the boxes and the horn-blocks, the boxes being provided with double inclined caps of wrought iron. The total wheel-base of the engine is 16′ 3″, but the rigid wheel-base is only 8′ 8″. The wheels are all of wrought iron, with crucible steel tires, secured by an outer clip fastening and set screws. The frames are of wrought iron 1′ thick, 1′ 6″ deep for the main part of their length, and 4′ 1½″ apart. The buffers are of wrought iron. The boiler is of the flushed-topped fire-box type, with plates arranged telescopically." The diameter of the boiler is 4′ 1″ inside the smallest plate. The fire-box casing is 5′ 10″ long outside by 4′ ½″ wide at the bottom, and 4′ 11″ deep below center line of the boiler. The boiler-shell is of Bowling plate; sides, barrel, and top of fire-box casing are ½″ thick, and the front and back plates $\frac{9}{16}$″. The smoke-box tube-plate is ⅞″ thick, and is flanged forward to join the smoke-box plates, it being connected with the barrel by an angle-iron ring. The inside fire-box is of copper, the plates being ½″. thick, except the upper part of the tube-plate, which is about ⅞″ thick. The fire-box crown is stayed by longitudinal roof-stays and by sling-stays, as shown. The boiler contains 219 brass tubes, 1⅞″ in diameter, 10′ $6\frac{3}{16}$″ long between the tube-plates, and Nos. 12 and 14 wire-gage thick at the fire-box and smoke-box ends, respectively.

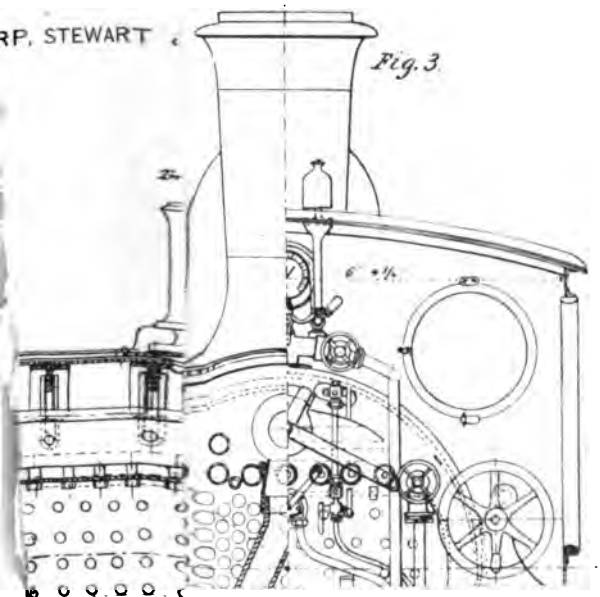
The safety-valves are arranged to blow at a pressure of 140 lbs. per square inch, and are placed on top of the fire-box casing. The boiler is supplied by two injectors, one No. 7 and one No. 9. The cylinder and valve casings are oiled by means of an automatic lubricator, of which the details are indicated in the figures. There is a large dome on top of the boiler, on which is the regulator.

Plate No. 6

E AT

RP, STEWART

Fig. 3.



GREAT BRITAIN.

Heating surface, etc.	Square feet.	
Heating surface of tubes, outside surface	1,134.00	
Heating surface of fire-box	105.00	Locomotive of Sharp, Stewart & Co. Plate 6.
Total heating surface	1,239.00	
Fire-grate area	17.70	
Sectional area through tubes	3.29	
Least sectional area of chimney	1.23	
Ratio of total heating surface to grate surface	70 : 1	Dimensions.
Ratio of grate surface to sectional area of tubes	5.38 : 1	
Ratio of grate surface to least sectional area of chimney	14.4 : 1	
Ratio of tube surface to fire-box surface	10.8 : 1	

Exhibits of—Robert Fairlie. Fox, Walker & Co. Black, Hawthorn & Co.

There were several locomotives of exceptional types exhibited in the British section, particularly those of Mr. Robert Fairlie, of Fox, Walker, & Co., and of Black, Hawthorn, & Co. These will be considered in another connection in this report. There was also an excellent locomotive exhibited by the London, Brighton, and South Coast Railway Company, which, in its finish and beauty and simplicity of construction, was worthy of high commendation.

London, Brighton, and South Coast Railway.

Railway rolling stock.

Railway rolling stock.

The plan of the passenger cars generally adopted in Europe possesses marked differences from that usually prevailing in America; but a few examples will suffice to present a fair view of the European system, and to exhibit the points of contrast between it and our own.

Countries exhibiting.

There were 48 railway cars exhibited at Paris, of which 31 were from France, 7 from Austria-Hungary, 4 from Belgium, 3 from Sweden, 2 from Italy, and 1 (a Pullman sleeping-car) from the United States.

FRANCE.

FRENCH RAILWAY CARS.

The French exhibit of railway rolling stock was not only the largest, but much the most satisfactory, because the most fairly representative of the practice of the country it was designed to illustrate.

First-class passenger coach, Western Railway Co. Plate 7.

The collection of the Western Railway Company of France contained some fine exhibits of railway rolling stock. The illustration, Plate 7, represents a beautiful first-class passenger coach, containing four compartments, exhibited by

FRANCE.

First-class coach, Western Railway Co. Plate 7.

this company. Each compartment is designed to seat comfortably eight persons. The interiors of the compartments are handsomely upholstered; the window-frames are surrounded by moldings trimmed with velvet; the lower joints of the doors are trimmed with Wilton carpeting; the seats and the sides, front, and back of each compartment are cushioned luxuriantly. All the appointments of the car are sumptuous. It is supplied with fixed ventilators, a double floor, and double ceiling, and at night the compartments are lighted by large lamps.

Description.

The frame is of iron. India-rubber cushions are placed between the body and the frame, and the springs are mounted with suspension loops. This car is intended for service in fast trains, and is furnished with the Westinghouse air-brake.

*Principal dimensions and weights.**

Dimensions.

Frame supports of iron cross-beams, wood:		
Total length over buffers		9.250 meters.
Length of frame over lead-stocks		8.150 meters.
Carrying-springs:		
Number of plates		14
Breadth and thickness		90 x 10 millimeters.
Length of top plate between points of suspension		2.000 meters.
Deflection per ton of load		90 millimeters.
Draw and buffer springs:		
Number of plates		13
Breadth and thickness		75 x 11 millimeters.
Length of upper plate	buffer	1.750 meters.
	draw	1.000 meters.
Deflection for each ton	buffer	75.000 millimeters.
	draw	12.500 millimeters.
Body of car:		
Greatest length of body of car along axis		8.270 meters.
Breadth at center		2.690 meters.
Breadth at ends		2.660 meters.
Height from floor to roof, interior, at center of compartment		1.950 meters.
Number of compartments		4
Area of floor of car		19.950 sq. meters.
Space allowed each passenger (including seat room)		9.050 sq. feet.
Running-gear, three axles:		
Diameter of spindles		0.100 meter.
Length of spindles		0.180 meter.
Diameter of axle at center		0.130 meter.
Diameter of axle near the journal		0.145 meter.
Diameter of axle at the journal		0.150 meter.

* The dimensions in this and other cases are given in meters to conform to the drawings, which are laid off by the metrical scale.

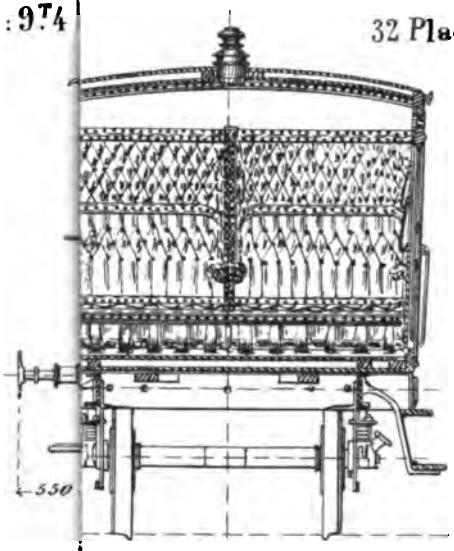
Plate No. 7.

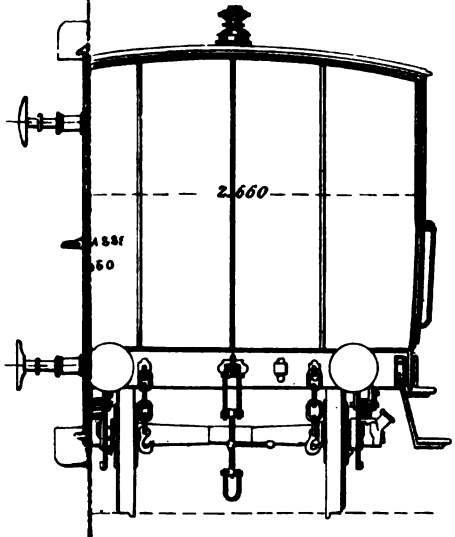
Série A, Nos.

Type 1877.

Tare : 9.74

32 Places





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FRANCE.

Wheels, type "Mansell" (tires of steel, cores of iron):	
Thickness of iron core	0.130 meter.
Diameter within tire	0.920 meter.
Diameter from out to out of tire	1.030 meters.
Weight of car, empty	21,384 lbs.
Maximum load, each passenger and his hand-baggage being estimated to weigh 165 lbs.	5,280 lbs.
Weight for each passenger	825 lbs.
Cost of coach at factory, including brake	$3,000
Ratio of diameter of spindles to that of the wheels	0.097
Mean weight of each axle, mounted	2,050 lbs.
Wheel-base	17 ft. 10 in.
Maximum load per axle	6 tons.

First-class coach, Western Railway Co. Plate 7.

Load, cost, etc.

There were two very comfortable and elegant *salon* cars exhibited in the French section, one shown by the Northern Railway Company, affording accommodations for not more than twelve persons, and one designed and manufactured by M. E. Chevalier, Paris. The latter was designed to accommodate a family or small party traveling together. It was subdivided into a salon, a sleeping apartment, a kitchen, a lavatory, etc. It could accommodate only six passengers and two servants. Both of these cars were handsomely finished and comfortably arranged, but were deficient in economy of space, and in this respect vastly inferior to the system of drawing-room and sleeping cars in use upon the railways of the United States, of which latter class of vehicles the Pullman sleeping-car exhibited in the American section was a splendid illustration.

M. E. Chevalier.

Family coach.

AUSTRIA-HUNGARY.

AUSTRIAN RAILWAY CARS.

There were in the Austrian section several passenger coaches and one postal car, all of which were creditable examples of the railway practice of that country. There were also exhibited some designs of very well arranged cars and coaches in the service of the Austrian State Railway Company. These do not differ radically from the cars used upon the railways of other European countries.

Views are given of three of the passenger cars of this company in the accompanying illustrations.

Passenger coaches Austrian State Railway.

Fig. 1 represents a first-class passenger car. The two middle *coupés* are in the ordinary style of compartments for first-class passengers; the *coupés* at each end are provided with shifting seats, which may be so adjusted as to enable the passenger to recline comfortably, called *fauteuils-lits*.

First-class coach. Figure 1.

AUSTRIA-HUNGARY.

The middle compartments seat six passengers each, and the *coupés à fauteuils-lits* three each. The principal dimensions of the car and compartments are indicated in the engraving in meters.

Austrian State Railway; first-class coach. Figure 1.

The weight of the car is 9 tons; weight for each passenger carried, 1,110 lbs.; number of passengers carried, 18.

Second-class coach. Figure 2.

Fig. 2 represents a second-class passenger car of the Austrian State Railway Company, built in 1876, giving an exterior and interior view. The frame is of iron and wood; the panels of the body of sheet-iron, as is also the roof; the seats and backs are upholstered with green morocco and the panels with oil-cloth; it has four compartments, each seating 8 persons. The car weighs 9½ tons, or 660 lbs. for each passenger carried. The principal dimensions are indicated in the engraving in meters.

Third-class coach. Figure 3.

Fig. 3 gives an exterior and interior view of an ordinary third-class passenger car of this company and its principal dimensions in meters. The frame is of wood and iron; the panels and roof of sheet-iron; wooden benches, with seats and backs uncushioned. Weight of car, 17,700 lbs.; weight for each passenger carried, 390 lbs.; number of passengers carried, 50.

Freight car. Figure 4.

Fig. 4 represents a freight car of the ordinary type in use upon the Austrian State Railways. The frames are of wood and iron, roof of sheet-iron, frame of the body of car of oak, with vertical strips of hard-pine plank from the top to the bottom. Weight of car without the brake, 13,630 lbs.: maximum load, 10 tons; dead weight for each ton of load, 1,265 lbs.

A sleeping-car, elegantly finished and comfortable in its appointments, of a type recently introduced upon the Austrian State railways, merits a fuller notice.

Sleeping car. Plate 8.

This coach, Plate 8, was designed after a careful study of the different kinds of sleeping-cars in use in Europe and America, and was intended to supply a want which was felt not to have been fully met by any of the types heretofore introduced.

The plan of these coaches is entirely experimental, but it is hoped that a fair trial will show them to be what is claimed for them, an improvement upon the older styles of sleeping-cars, at least in respect to the demands of European travel. They are manufactured at the workshops of the company at Simmering.

Description.

The car comprises two divisions. The first division embraces two compartments, each of which may in turn be subdivided into two separate sections, in each of which the

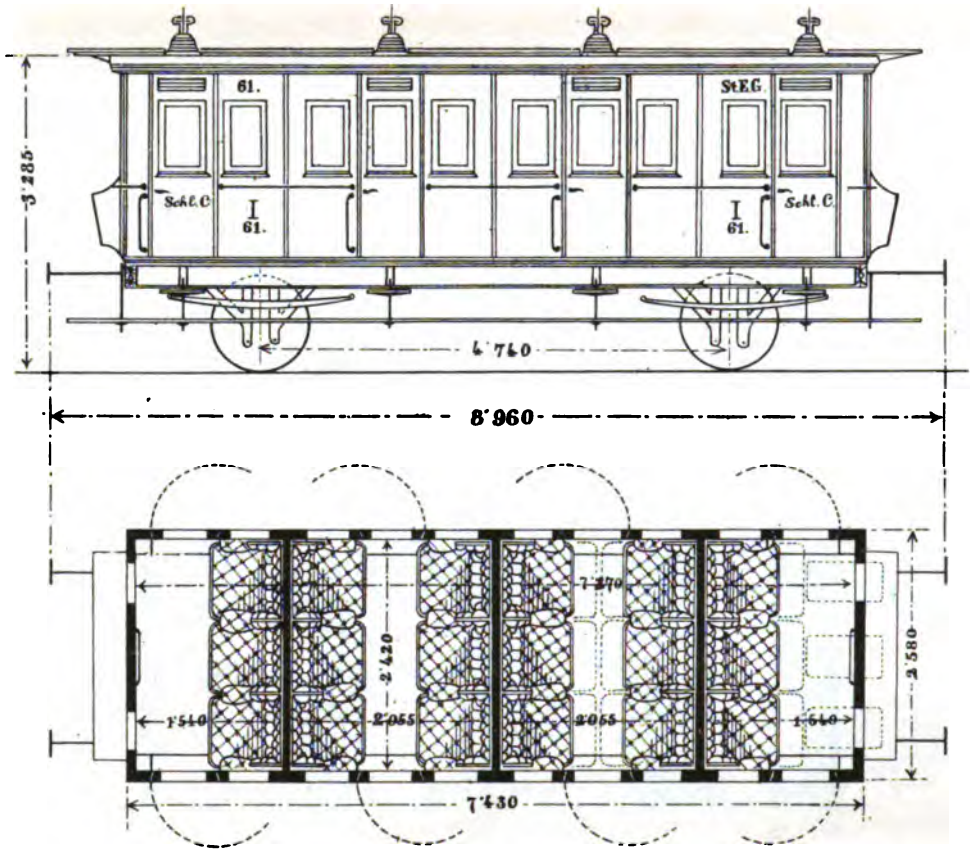


Fig. 1.—A 1st-class passenger coach, the compartments at each end being provided with "Sleeping Chairs."

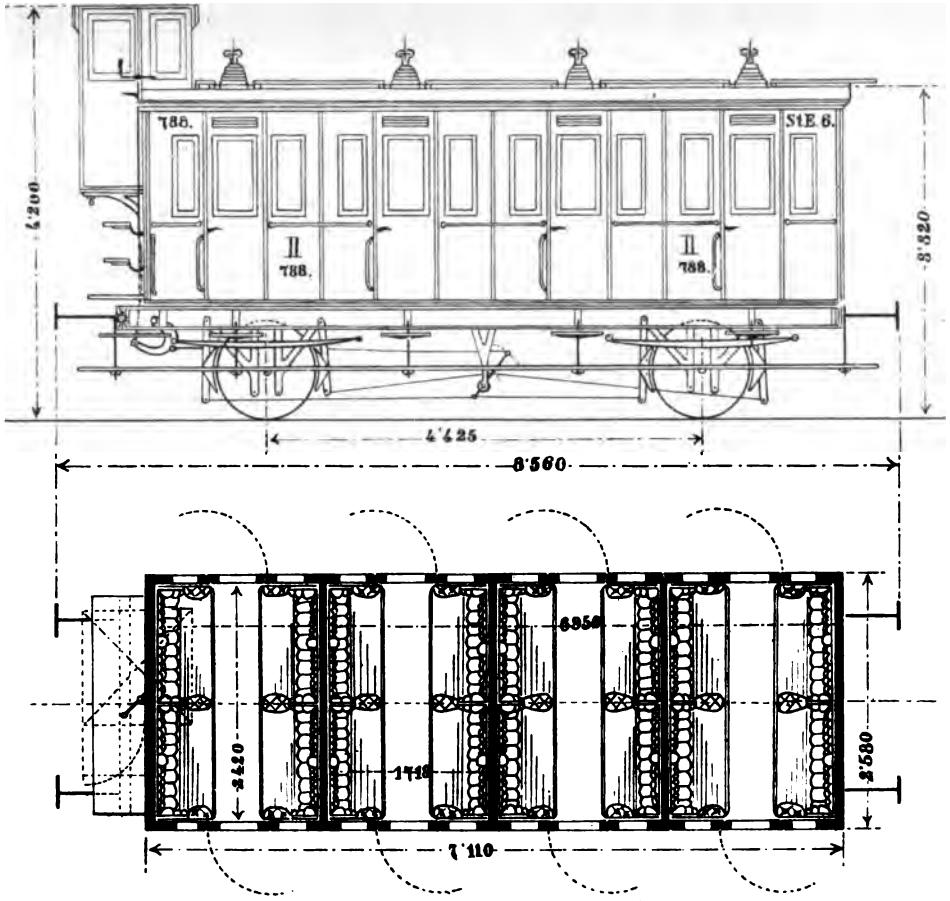


Fig. 2.—2d-class passenger car of Austrian Railway Co.

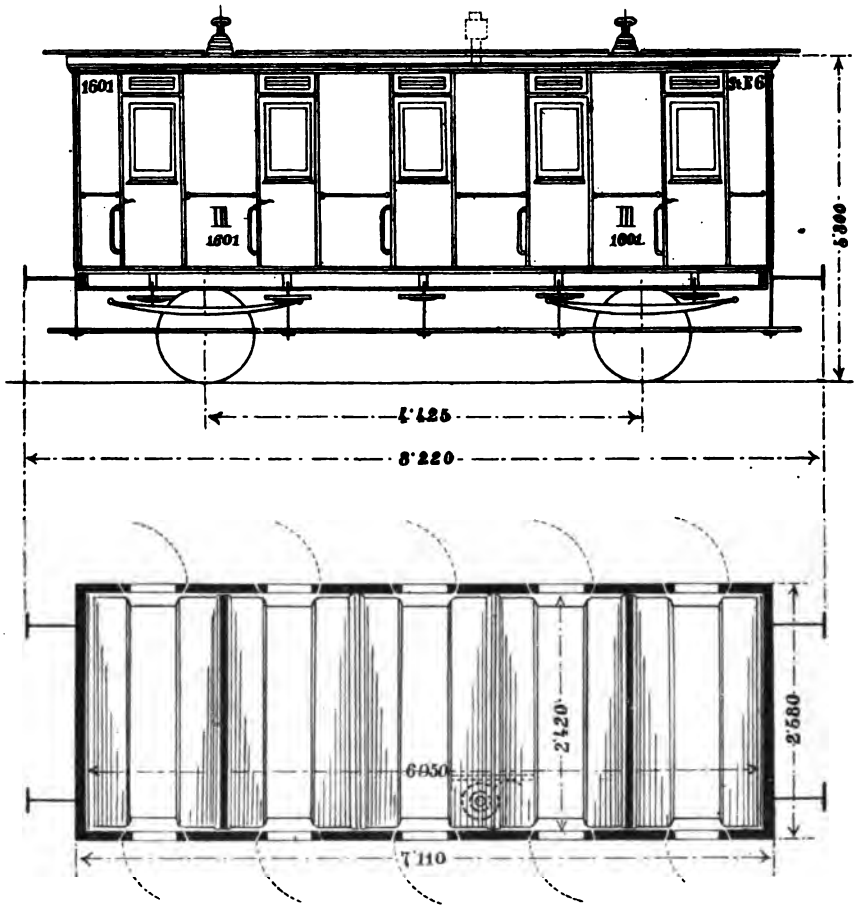


Fig. 3.—3d-class passenger coach of Austrian Railway Company.

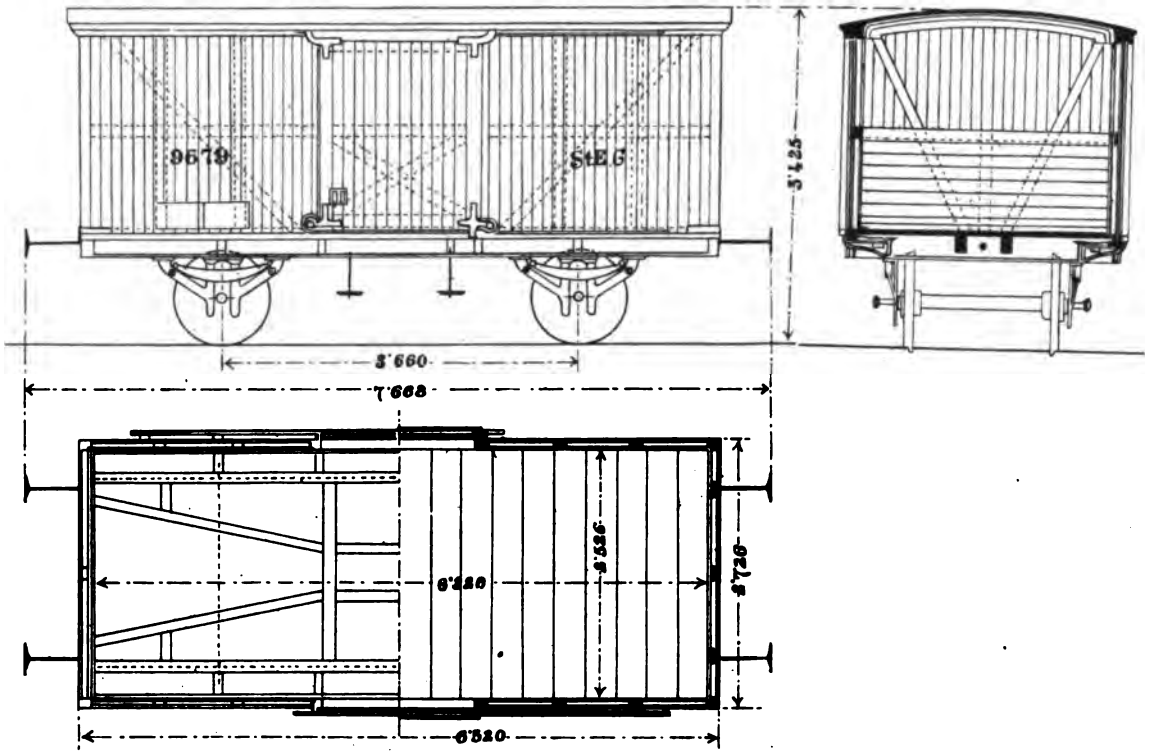
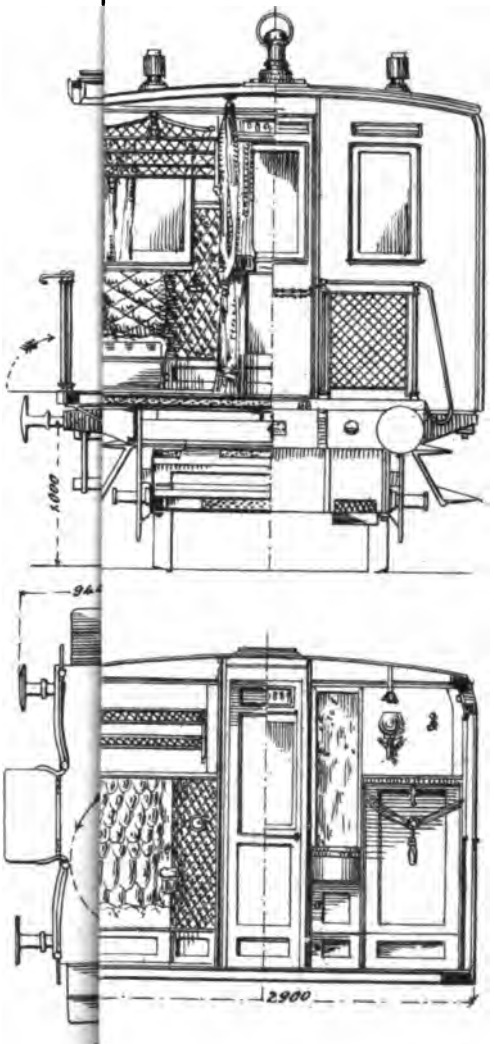


Fig. 4.—Ordinary covered freight car of the Austrian Railway Company.

Plate No. 8.



NY.

UNIV. OF WISH.

passenger may sleep and make his toilet. The second division comprises three distinct compartments, in each of which the traveler may sleep and make his toilet in privacy. AUSTRIA-HUNGARY.

Each of the first two compartments affords accommodations for four, and upon an emergency six, persons during the day and two at night. The whole car will thus afford sleeping accommodations for seven persons, and in the daytime will seat eleven, and if necessary thirteen, persons. It is provided with lavatories and a water-closet; a place for the guard; a closet for bed linen, etc.; and, what is extremely rare outside of the United States and Canada, a water-cooler for iced drinking water. As will be seen from the illustration, Plate 8, a passage runs through the whole car, so that there may be ready communication between the different sections and compartments. This passage, however, is closed by a door between the first and second division and again between the two compartments of the first division. The compartments have double windows, one of the sashes being furnished with glass and the other with blinds of wire gauze. At night the passage is lighted by means of lamps and the compartments are lighted by candles. Austrian State Railway. Sleeping-car. Plate 8. Description.

The extreme wheel-base is 15.925′. The total weight of the car in running order is 27,770 lbs. The dead weight for each passenger carried is, at night, 3,968 lbs.; by day, with eleven passengers, 2,526 lbs., or with thirteen, 2,136 lbs.

The enormous dead weight which such an arrangement of a coach necessitates renders it far from economical, but apart from considerations of economy the car is an extremely comfortable and luxurious one.

Narrow-gage railways, tramways, engines, and cars.

Narrow-gage railways.

Notwithstanding the profound attention which the question as to the proper gage to be adopted for railways has received at the hands of railway engineers and constructors, and the immense sums expended in practical experiments as to the special advantages of the various gages which have been suggested, the question cannot be regarded in Europe, any more than in America, as finally settled. The question of gage not settled.

The gage adopted in Germany and generally throughout Europe is 4′. 8½″. between the rails. The gage in France upon the main lines is 4′ 8½″ and 4′. 9″. Still, there are men, thoroughly acquainted with the subject, who insist that under certain conditions, existing to a greater or less extent in large sections of almost every country, a gage narrower than the standard width should be adopted, and Standard European gage. French gage.

Narrow-gage railways.

they urge the advantages of cheapness of construction and economy and efficiency of working roads of the width of a meter, or a little more or less, with as much earnestness, and their views are combatted by the advocates of the prevailing gage with as much vehemence, as though the battle were freshly joined. The feeling manifested in these discussions must occasion some surprise to one who brings to the consideration of the subject no preconceived notions and no prejudices or special predilections.

The battle of the gages.

Advocates of the broad, standard, and narrow-gages.

Among the advocates of the broad, the standard, and the narrow gages respectively there are men whose studies and attainments, whose skill, and practical acquaintance with the subject entitle their conclusions to respect and confidence, but the tests of practical experience are of yet greater value. The results obtained from the trial of the narrow gages have certainly demonstrated that under special conditions they possess many of the advantages claimed for them by their advocates. On the other hand, the enormous work being well and successfully done throughout the civilized world by roads of the standard gage, and the preference which the railway companies of the world, after years of discussion and experiment, still manifest for this gage, would seem to indicate that whether its adoption was originally a matter of accident or of design, it has been preserved as the gage of the greater part of the railways as yet built as a matter of convenience and of advantage, and not from a mere aversion to change or from caprice.

Arguments pro and con.

The special conditions where the narrow gage is indicated.

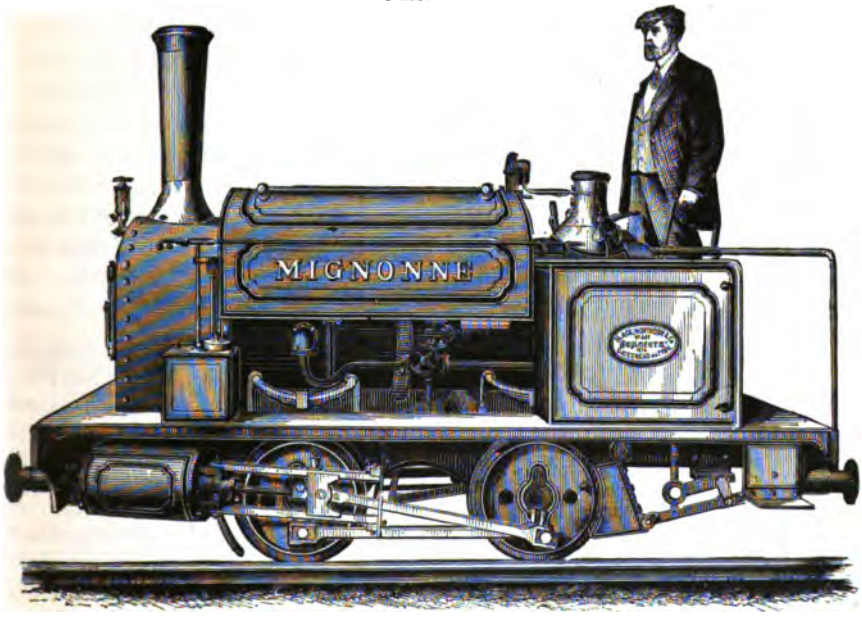
The experience of narrow-gage roads seems to have shown that for regions not thickly inhabited, not affording a large railway traffic, presenting in the topography of the country difficulties of construction by reason of the heavy gradients and short curves to be surmounted, the roads of less gage are the best, because, while they possess ample carrying capacity for the wants of such a country, they are more cheaply built and more cheaply worked than roads of the ordinary width between the rails.

Our interest in the subject.

The subject is one of profound interest to all countries, and to none of more importance than to ours, with a vast territory yet unsupplied with adequate means of transport, with enormous resources yet to be utilized, and with a population ever ready to devote their energies with restless and resistless activity to pressing forward old and building up new industries.

In view of these considerations, the exhibits at the Paris Exposition connected with service upon narrow-gage railroads were studied with much interest.

PLATE 9.



SADDLE-TANK ENGINE—NARROW GAUGE (36″).

Black, Hawthorn & Co., Gateshead-upon-Tyne, England.

[Page 450, vol. IV.]

Narrow-gage railways.

There were admirably constructed engines exhibited in the sections of Belgium, Great Britain, and Austria which were designed for service upon tramways and narrow-gage roads.

Saddle-tank narrow-gage engine of Black, Hawthorn & Co. Plate 9.

One of the most perfect of these was the saddle-tank engine exhibited by Messrs. Black, Hawthorn, & Co., of Gateshead-upon-Tyne, England, a machine designed for service upon light railways of 3′ gage. It had outside cylinders and 4 coupled wheels. The action of the engine was simple and direct. There was no dome upon the boiler. The weight was so distributed as to equalize the burden upon the 4 wheels. The fire-box was of copper, the boiler-tubes of brass; working pressure 135 lbs. per square inch, or about ten atmospheres; the weight of the locomotive in fair working order is about 3½ tons, and it possesses a sufficient adhesion and tractive force to haul a load of 63 tons. The slides, piston-rods, valve-rods, crank-pins, cross-bars, and the tires are of the best steel, and the whole mechanism of the movement is of wrought iron, well chilled. This engine will pass with ease around curves of a radius not exceeding 20′. Plate 9 presents a side view of this locomotive ("Mignonne"). The principal dimensions are as follows:

Description.

Dimensions.

Diameter of cylinders	5 in.
Stroke of pistons	10 in.
Wheel-base	3 ft.
Length of boiler	4 ft. 10 in.
Diameter of boiler	1 ft. 10 in.
Thickness of boiler-plate	¼ in.
Number of tubes	31
Heating surface of tubes, about	57 sq. ft.
Surface of fire-grate	2 sq. ft.
Total heating surface	67 sq. ft.
Diameter of wheels	1 ft. 8 in.
Tires, best steel	4 in. x 1¼ in.
Diameter of journals	3 in.
Length of journals	4 in.
Capacity of tank	50 gals.
Capacity of coke-boxes	3 cu. ft.

The feeding apparatus consists of two No. 4 injectors. The boiler has been tested to 200 lbs. per square inch. The consumption of fuel is 289 lbs. of coke in 12 hours; that of oil, tallow, etc., is estimated at 14 cents for the same period.

Fairlie Engine and Rolling Stock Co.

The Fairlie Engine and Rolling Stock Company, of London and Bristol, exhibited a powerful and well-finished locomotive of the standard gage, from the designs of Mr. Robert F. Fairlie, the distinguished engineer, inventor, and

Narrow-gage railways.

manufacturer; also designs and particulars of a large number of engines of the types introduced by Mr. Fairlie for service upon narrow-gage roads, numbers of which are represented to be in actual and successful use upon railways of

Fairlie Engine and Rolling Stock Co.

Narrow-gage engine. Figure 5.

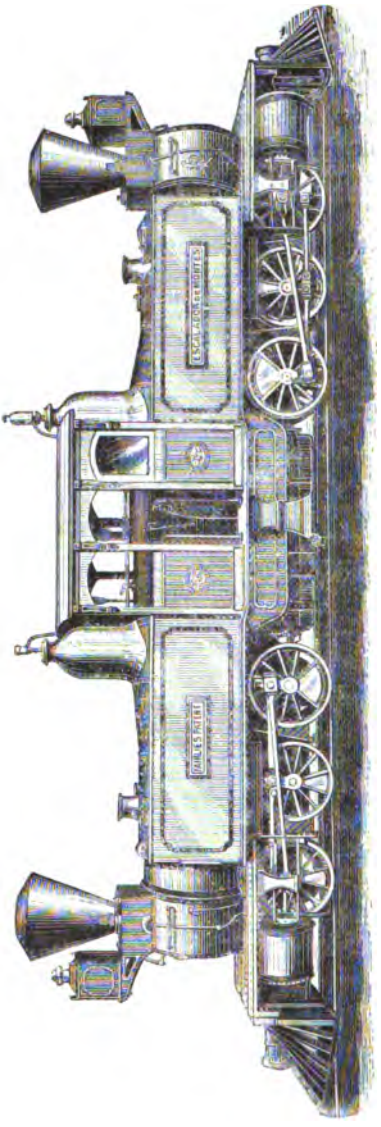


FIG. 5.—*Double-boiler, double-bogie Fairlie engine for 3′ gage. Built for the Venezuelan Government railways by the Fairlie Engine Company, Bristol, England.*

gages ranging from 1′ 11½″ to the standard gage, in Wales, Ireland, Russia, Norway, Australia, South America, Mexico, and elsewhere.

The accompanying engraving (Fig. 5) represents an engine of the Fairlie system built for a road of 3′ gage.

Narrow-gage railways.

This locomotive has 4 cylinders, of 13½″ diameter, 18″ stroke of pistons; 12 wheels, of 3′ 3″ diameter, all coupled; aggregate heating surface, 1,325 square feet; capacity of water-tanks, 1,450 gallons, and of coal bunkers, 1½ tons; weight of locomotive in working order, 45 tons. All the wheels being coupled, the whole weight is available for adhesion, and the traction force at the rails is 16,200 lbs. The mean cylinder pressure is 100 lbs. per square inch. Several machines of this type have been built for the Venezuelan Government railways, and engines of the same special design have been built upon a large scale for the Pisagua Railway of Peru, a line having gradients as steep as 1 in 25, and curves of 250′ radius.

Fairlie engine. Figure 5.

Description.

Engines for South American roads of steep grades, and curves of short radius.

The following advantages, among others, are claimed for the locomotives of this system:

Advantages of the Fairlie engine.

(1) That the arrangement of the running-gear and the short wheel-base enable the Fairlie engine to pass around short curves without injury to the track or strain upon the machine, and the arrangement of the under frames to the boiler admits of free movement, vertical and horizontal.

(2) That the whole weight of the engine is available for adhesion, while yet the wheel-base is short, and that the weight is so distributed as to reduce the load per wheel so greatly that a lighter rail may be employed than could be safely used with an ordinary and much less powerful machine.

(3) That the large heating surface secured will enable a narrow-gage engine to haul with ease up long and steep gradients a load with which it would be impossible for an ordinary locomotive to mount such ascents, because the steam upon the ordinary locomotive would, under such conditions, give out, while the water-level over the fire-box remains in the Fairlie engine always constant.

(4) That it will do the work of two ordinary engines coupled together much better than it would be possible for them to do it, for the reason that two machines coupled together, with a full load behind them, would drop their steam as quickly as one, and because, while the water-level would be very high over the fire-box in one of the locomotives, the fire-box of the other might be uncovered.

(5) That the Fairlie engine develops more power and at less cost than could be realized with two locomotives of the same vital dimensions of the ordinary types.

(6) That they ride smoothly over roads upon which the ordinary locomotives would move with difficulty.

(7) That by reason of the above advantages, and particu-

Narrow-gage railways.

larly of the fact that the power of these locomotives is not limited by the width of the track, "they solve the problem of narrow gage and make such lines as efficient as lines of the greatest width."

No little attention has been bestowed upon the subject of narrow-gage railways in Great Britain and upon the Continent by railway engineers and constructors.

FRANCE.

FRANCE.

Conclusions of the French engineers.

M. E. Villevert.

The result of the experience and studies of the engineers of France may, in the language of M. E. Villevert, a distinguished engineer of that country, be summarized as follows:

> That the lines of general interest and those of international and strategic importance should be constructed of the ordinary 4 ft. 8½ in. gage already adopted by the principal railway companies of the world, so as to allow the free movement of trains and transportation of merchandise, war material, passengers, and troops without change of cars or breakage of bulk.

Uses of the narrow-gage system.

It is urged, however, that there should be in France an extensive system of narrow-gage roads auxiliary to the lines of standard gage; that narrow-gage roads should be built wherever the lines are merely of local interest and will not give an adequate return for the outlay necessary for the more expensive plant of the broader gage.

Dimensions of narrow-gage road-bed and way.

The roads of narrow gage now being advocated in France are of the following description: Gage, 1 meter (39.371 in.); width of road bed, 12′ 4″ in cuts, and upon fills from 11′ to 11′ 8″; the masonry of undressed stone, built in the ordinary way; the ballast to be 12″ thick; cross-ties 6′ 6″ long, 7⅘″ wide, and 5⅘″ thick; rails to weigh 34¼ lbs. per yard.

Cost per mile.

The whole cost of such a road in France under ordinary circumstances is estimated to be about $29,000 per mile—far less than half the average cost of the railroads of standard gage heretofore built in that country. The depots, bridges, and works of art generally are projected upon a much less expensive scale and less durable and desirable materials and modes of construction than those in use upon the standard roads. The cost of a road of a meter gage, built in the thorough manner in which the roads of standard width are usually constructed, would—including fixtures, depots, shops, rolling stock, etc.—probably cost, upon the same scale of comparison, from 60 to 75 per cent. of the cost of 4′ 8½″ a road, taking the roads already built in France as criteria.

Diminished scale of permanent erections.

Relative cost of standard and narrow gages.

GREAT BRITAIN.

Narrow-gage railways.

In Great Britain and in the British colonies and dependencies earnest and enlightened consideration has been given to the subject of the construction of narrow, cheap, and economical railways. The most remarkable, as it is the most successful of all the narrow-gage roads to which my attention has been called, is the well-known line of 2′ 11½″ gage from Port Madoc to Festiniog, Wales.

Port Madoc and Festiniog Railway.

The conditions under which this line has been built, developed, and worked have been exceptional; but its success is connected with points of practical interest to many regions in our own country; and while it may be regarded, perhaps, rather as a curiosity than a precedent, still the results accomplished by this railway in miniature are so remarkable that it may not be an unprofitable task to examine the system of this extraordinary line at greater length.

Length.

The road is built from the shipping port above mentioned to Dinas, in the vicinity of immense slate quarries among the mountains, some twelve or thirteen miles from the coast.

Difficult region traversed.

It traverses a wild, difficult, and rugged region, overcoming about 700 feet of elevation in twelve and one-quarter miles,

Gradients and curves.

the gradients attaining a maximum of 1 in 67, and curves of 3, 4, 5, 6, 8, 10, and 15 chains radius, with one curve of 116 feet. Since 1863 this road has been operated by steam motive power.

Track.

The track is laid with double-headed iron rails, weighing 50 lbs. to the yard. The permanent way, track, locomotives, rolling stock, and the other necessary appointments of the line are constructed in a thorough and substantial manner.

Cost.

The total cost of the thirteen and one-quarter miles, including all outlays for roadway and appurtenances and large expenditures incurred in adopting a number of changes and improvements upon the original design, has been £86,000 for the whole line, or about $30,660 per mile for plant and equipment. In view of the fact that this is only about one-sixth of the average cost per mile of the roads of standard gage in England and Wales, the disparity in cost is remarkable.

Such is the exceedingly difficult character of a portion of the ground over which the road is built that the cost of a single mile of the line, according to the estimate of the engineer, Mr. C. E. Spooner, would have been, had it been attempted to build a road of 4′ 8½″ gage, as much as the cost of the entire line has actually been.

Return for capital invested.

The road has made steadily a net revenue for its owners upon the whole amount of capital invested of from 6 to 13

GREAT BRITAIN.

Narrow-gage railways.

per cent. per annum, and it is proper to add that of the £86,000 actually represented as invested, £50,000 have been accumulated out of the annual revenues.

Port Madoc and Festiniog Railway.

The rolling stock embraces 9 locomotives, of which 2 are double-bogie Fairlie engines with double boilers, 4 coupled wheels to each bogie; wheels, 32″ in diameter; cylinders, 8½″; wheel-base of each bogie, 4′ 6″; total wheel-base, 19′; weight, 22 tons: 2 others with 4 wheels coupled; 8″ by 12″ cylinders; 5′ wheel-base; diameter of wheels, 2′; weight of machine, 10 tons: 4 of 4 coupled wheels, having

Rolling stock.

4′ 6″ wheel-base, and weighing 8 tons: and 1 single-boiler double-bogie Fairlie, with 8½″ cylinders; 14″ stroke; wheels, 32″ in diameter; wheel-base of leading bogie, 4′ 6″, of trailing bogie, 3′ 6″; total wheel-base, 13′.

Types of passenger cars.

The passenger cars of this line embrace three types: (1) One having 4 wheels, length of car 12′, width 6′ 3″, seats arranged longitudinally, the passengers sitting back to back, six upon each seat; (2) the second type, 4-wheel cars, divided into two compartments, each seating six persons; (3) bogie cars, composite, with first, second, and third class compartments, built 36′ or 32′ long, 6′ wide, the 36′ cars carrying six first, six second, and thirty-six third class passengers, and the 32′ cars six first and forty third class passengers, maximum seating capacity. The seats are arranged as in the *coupés* upon the prevailing type of passenger coaches in use upon the European roads.

Mr. C. E. Spooner.

"Little Wonder."

The writer rode over this road twice, and through the courtesy of Mr. C. E. Spooner was permitted to ride upon the locomotive, "Little Wonder," and also upon the bogie passenger coaches and one of the slate-wagons—the last of a train of some thirty cars and wagons. The smoothness with which the train passed the sharp curves and over the heavy grades of this miniature line, the freedom from unpleasant shocks and jars, the remarkable evenness and absence of oscillation in the running of the locomotive, even upon the difficult portions of the line, were greatly to be admired.

The whole of the rolling stock is provided with central couplings and buffers, which greatly facilitate the passage of curves.

Speed.

The trains are run at a speed of from 10 to 25 miles an hour, sometimes attaining a velocity of 30 miles or more without injury to the rolling stock or track.

The line in its construction and equipment and management is a monument to the engineering skill and the effi-

ciency and faithfulness of the officers of the company and their assistants.

Portable railways.

Portable railways for farms, mines, etc.

M. Decauville.

M. Decauville, sr., of Petit-Bourg (Seine-et-Oise), exhibited an iron tramway and its equipment, manufactured at his establishment at Petit-Bourg, near Paris, which are admirably designed to meet a felt want for a cheap and reliable means of transportation for more or less temporary use in the service of mines, in forest and factories, and in connection with large agricultural operations, such as those upon a sugar plantation.

Rail.

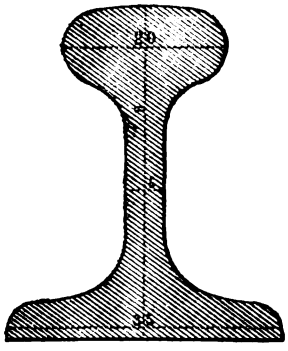


FIG. 6.—*Section of rail for farm and mine tramways (full size).* (*Decauville, Petit-Bourg.*)

Rail-joints.

FIG. 7.—*Joint for iron tramway sections.* (*Decauville, Petit-Bourg.*)

Description of track.

This tramway (Figs. 6–10) consists of a movable iron track formed in sections, the rails being connected at intervals by iron cross-bars. The sections are united to each other, as the track is laid, by fish-joints arranged so as to be securely and readily bolted to the rails of the sections to be connected. The sections are from 4 to 18′ long, according to the gage of the road, purposes for which it is to be used, nature of ground, and other conditions. The gages generally used are 15″, 19″, and 24″. The rails are made of Bessemer steel, are miniature inverted T rails, and weigh usually 8½ lbs. per yard. The rails and the

Portable railway.

M. Decauville.

Description.

flat cross bands connecting them are intended to lie flat upon the ground. These connecting cross-bands or bars are arranged at intervals of 4′ or less. A track of either of the gages mentioned will, it is claimed, bear a normal weight of one ton for each car-axle if it rests upon a smooth and solid surface, and if located upon an irregular surface, as would generally be the case when used for a temporary purpose, would sustain a burden of one-half of a ton for each axle. The annexed figures fairly represent the rails used for this tramway and the method adopted for connecting the sections of the track. A complete section of track

Tramway cars.

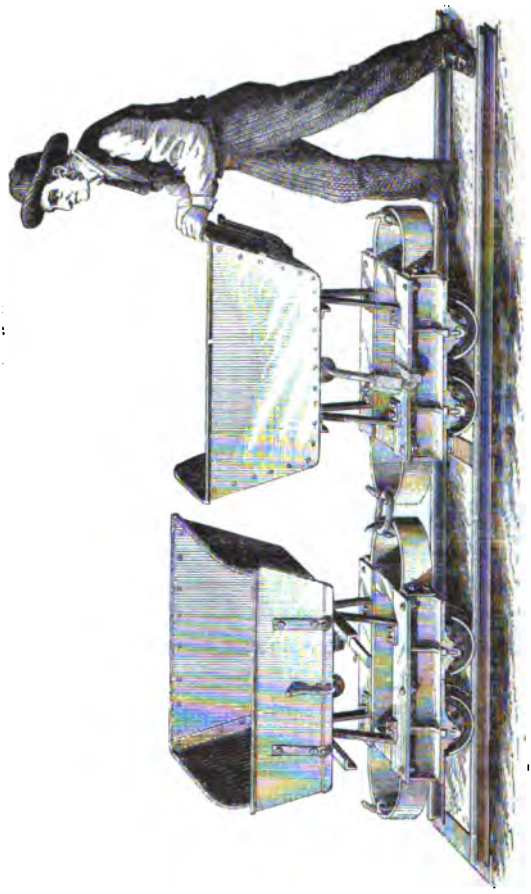
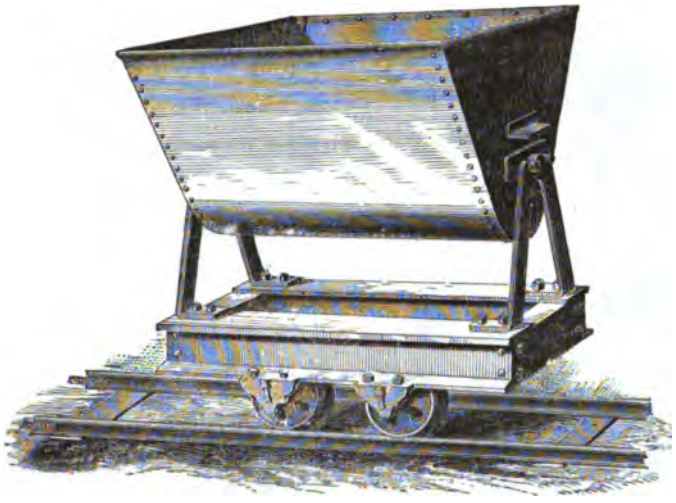


FIG. 8.—*Decauville's tramway and cars for use in mines and quarries.*

18′ in length will weigh about 104 lbs., and can be readily carried by one man. The track can thus be rapidly taken up, moved, and relaid. Sections of curved rails and short sections are provided for turning curves.

The wagons are constructed with 4 and sometimes with 6

wheels, and of various designs, according to the uses for which they are intended, and are designed to carry from 500 to 2,000 lbs. or more, each, according to the character of the ground and the weight of the rail used. *Portable railway.* M. Decauville.



Dumping cars.

FIG. 9.—*Decauville's tramway car used in mines.*

The accompanying illustrations (Figs. 6–10) illustrate the plan of constructing this tramway, and some of the modes in which it may be used.

Street-railway cars.

Street-railway cars.

The designs of the cars in use upon street railways in Europe seem to have been generally borrowed from America. Those in use upon the tramways of Paris are admirably arranged, commodious, and convenient. Upon some of the lines of the "General Omnibus Company" of Paris, which operates many miles of tramways in that city, the cars are provided with a double row of seats upon the top, the passengers sitting on the top benches back to back, and they have conveniently designed stairways at each end for ascending to the top. General Omnibus Co. of Paris.

The larger cars, those on the principal lines, seat 20 passengers on top, 22 inside, and afford standing room for 6 passengers upon the platform. The guard never allows a larger number to get upon the car. These lines are managed with great system, and the cars are run with commendable regularity, and a marked regard is shown for the comfort and convenience of the passengers. Seating and standing capacity of cars.

Street-railway cars.

General Omnibus Co. of Paris.

Fares.

The fare for any distance upon any line or to any point upon a connecting line, with a "transfer" or "correspondence" ticket, is 6 cents below; for any distance upon the same line the fare on top is 3 cents, or with a "correspondence" for a connecting line 6 cents.

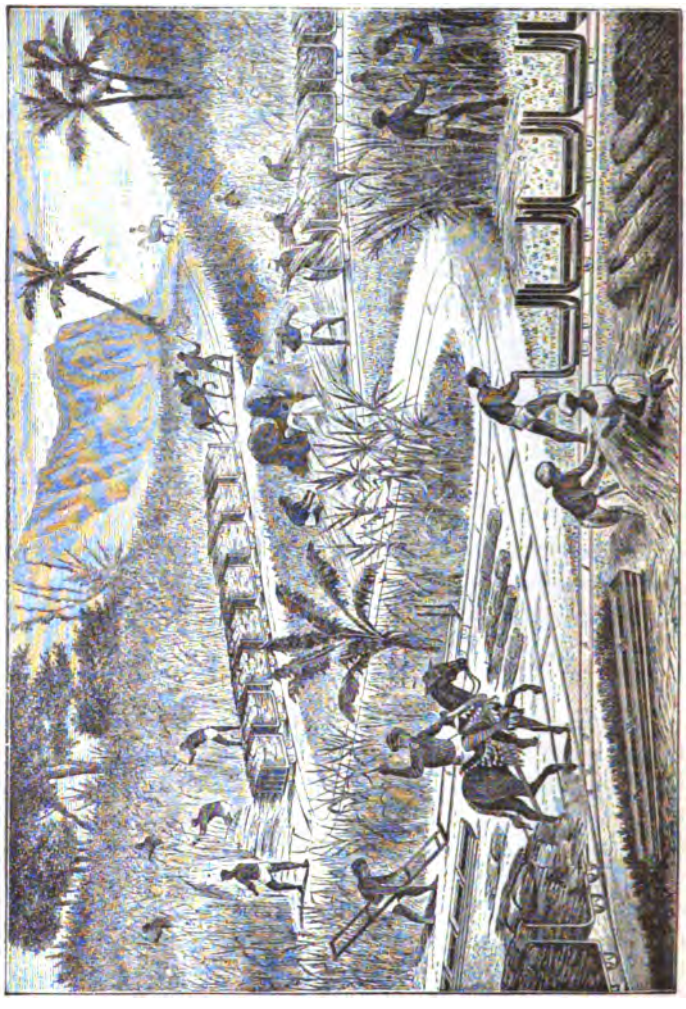


FIG. 10.—*Tramway of the Decauville system for sugar plantations.*

Inside and deck seats.

In keeping with the observance of class distinctions, so conspicuous everywhere in Europe, the top was designed originally for the peasant and laboring population of Paris, but in good weather the deck seats are considered by many persons the most desirable, and are occupied indiscriminately by all classes of passengers.

Street-railway cars.

The general plan and construction of the cars is that adopted in the United States, except that the wheels upon one side are made *without flanges*, so as to facilitate the passage of curves and the hauling of the car off from the track should any interposing obstacle obstruct the track and render it necessary to move the car around and on to the track again. The track is grooved, and the wheels upon one side of the cars are constructed with a flange or head, which runs in the groove of the rail.

General Omnibus Co. of Paris.

The track.

There were a number of cars and locomotives for use upon tramways in cities exhibited in the French and other sections. Among their attractive collections of exhibits none were more admired, and none of better workmanship or more tastefully, indeed beautifully, decorated, and more conveniently arranged, than the American street cars exhibited in the United States section, manufactured by J. G. Brill, of Philadelphia, and by the John Stephenson Company, of New York City. There were no cars for similar uses exhibited from any other country which were as well designed or of better finish than the three street cars exhibited by the manufacturers last named. They were of types too well known in this country to render any description necessary, but in the thoroughness and beauty of their execution and workmanship they have scarcely been ever surpassed in any country. The same may be said with equal emphasis of the car from the works of Mr. Brill.

American exhibit.

J. G. Brill.

John Stephenson Company.

Excellent in design and workmanship.

Compressed-air motors.

The engines and cars for service upon tramways exhibited by the *Société Générale des Moteurs à Air Comprimé*, are deserving of notice in this connection. The cars are of the ordidary type in use upon the street railways in Europe, as shown by the plate. The locomotive is of the system of M. L. Mékarski, and is propelled by means of compressed air. In some cases there is a single car and the motor is placed upon it, as indicated in Fig. 12. The "society" exhibited also a locomotive constructed upon the same principle, designed for service in mines.

System of M. Mékarski.

Figures 11, 12, 13.

The motor for hauling passenger cars upon tramways is designed for lines of easy grades; and for a course of from seven to nine miles the machine will, it is claimed, haul the cars carrying 46 passengers without being recharged. The reservoirs contain 450 lbs. of air, and the receiver incloses 40 gallons of hot water. The air is forced by powerful pumps into the receiver through the water, as indicated in

Length of course.

Mode of charging reservoir.

Compressed-air motors.

Fig. 11, until a pressure of 30 atmospheres is secured, when the machine is considered charged and ready for service.

System of M. Mékarski.

It is claimed that the motors of this system have been and can be used with great economy, and that upon the score of convenience it is to be preferred to any other motive power yet introduced for service upon street railways—

Superiority to steam cars.

(1) Because horses are not frightened by the noise and smoke, as is often the case where steam-engines are used upon thoroughfares;

(2) Because the dangers of explosion are avoided;

(3) Because they are run without sparks, cinders, or smoke.

Mékarski's compressed-air street-car motor.

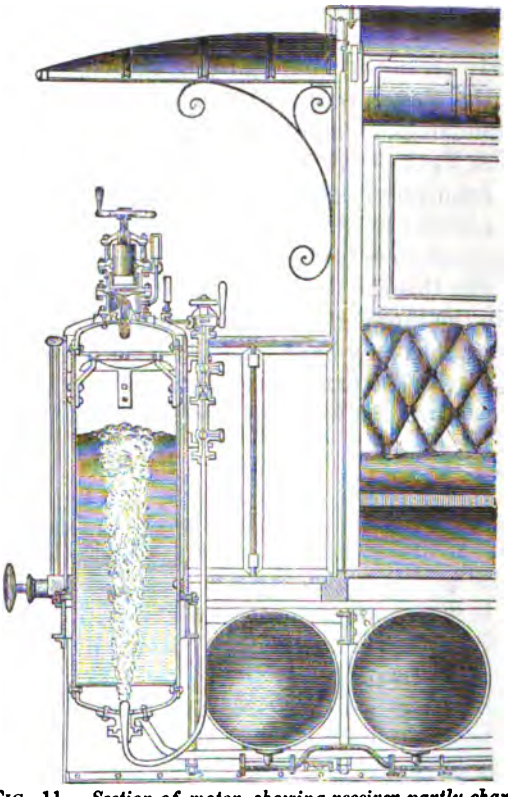


FIG. 11.—*Section of motor, showing receiver partly charged.*

Dr. Lamm's fireless locomotive.

The engine and cars intended for use upon street railways and tramways exhibited by the "Continental Company for the Manufacture of Fireless Locomotives," though, like the exhibits last described, of an exceptional and as yet an experimental type, were creditable to the skill and ingenuity of the gentlemen after whose designs they were built. The locomotive which embodies what is claimed to be new in the system is of the type introduced by the American in-

ventor Dr. Lamm, with certain improvements engrafted upon the invention of Dr. Lamm by M. Léon Francq. The system is substantially the same which has been in use upon street railways in the cities of New York and Brooklyn, and to a still larger extent upon the lines of street railway at New Orleans owned by the company of which General G. T. Beauregard has been the president. This system seems to be regarded by French engineers who have given it their careful attention as decidedly superior to that of M. Mékarski, known as the "compressed-air locomotives." Indeed, it has been pronounced to be the best substitute yet suggested for steam-locomotives or horses as the motive power of street cars.

Compressed-air motors.

System of Dr. Lamm, improved by M. Léon Francq.

Reference to uses within the United States.

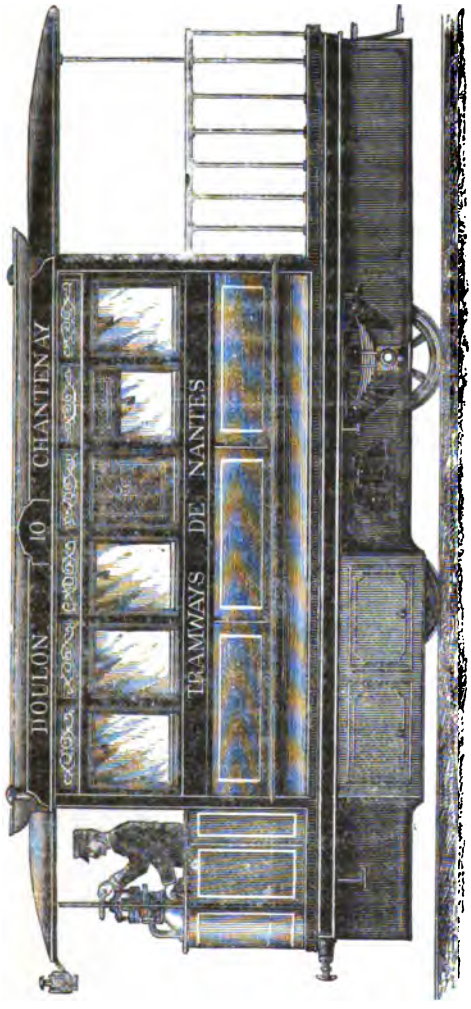


FIG. 12.—*Showing car with motor attached, the whole weighing 8 tons and seating seventeen passengers, with standing room for 13 passengers upon the platform.*

(Mékarski's compressed - air street-car motor.)

Comparison of the Lamm-Francq with the system Mékarski.

Compressed-air motors.

(Mékarski's compressed-air street-car motor.)

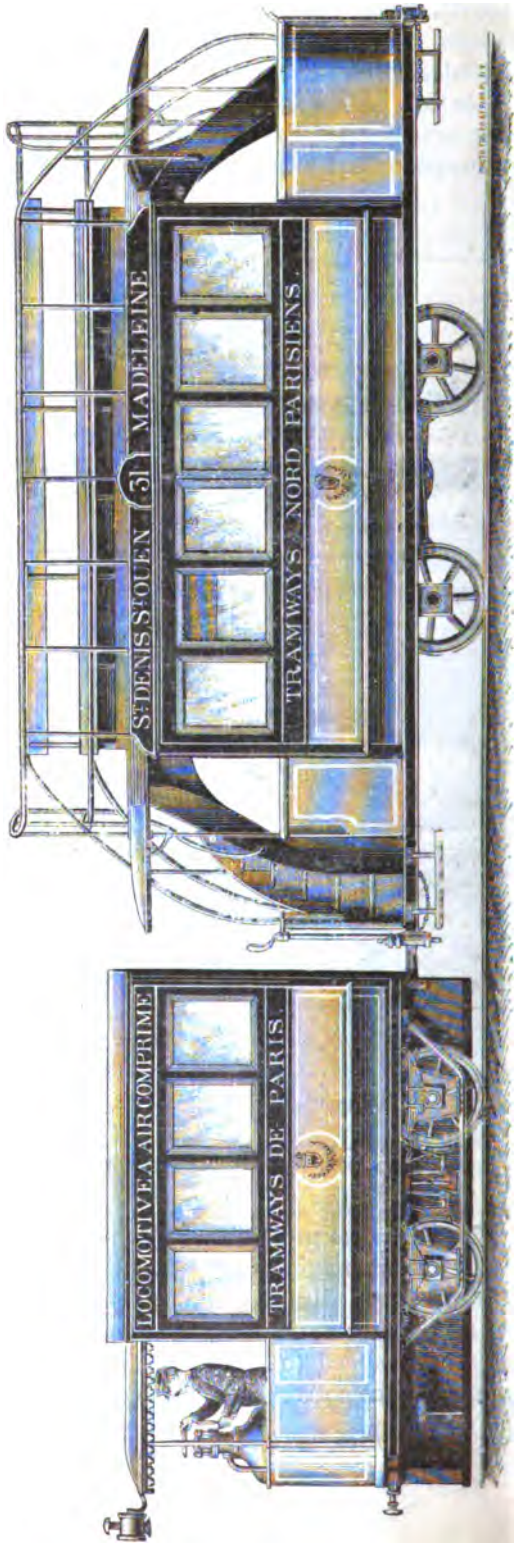


FIG. 13.—*Showing ordinary street car drawn by the compressed-air motor. Weight of the whole, in working order, 12 tons. Number of passengers carried: Interior, 16; top of car, 18; platforms, 12; total, 46.*

This system rests upon the application of the established physical fact that a pound of water confined in a tightly inclosed space will store up in the process of condensation

Compressed-air motors.

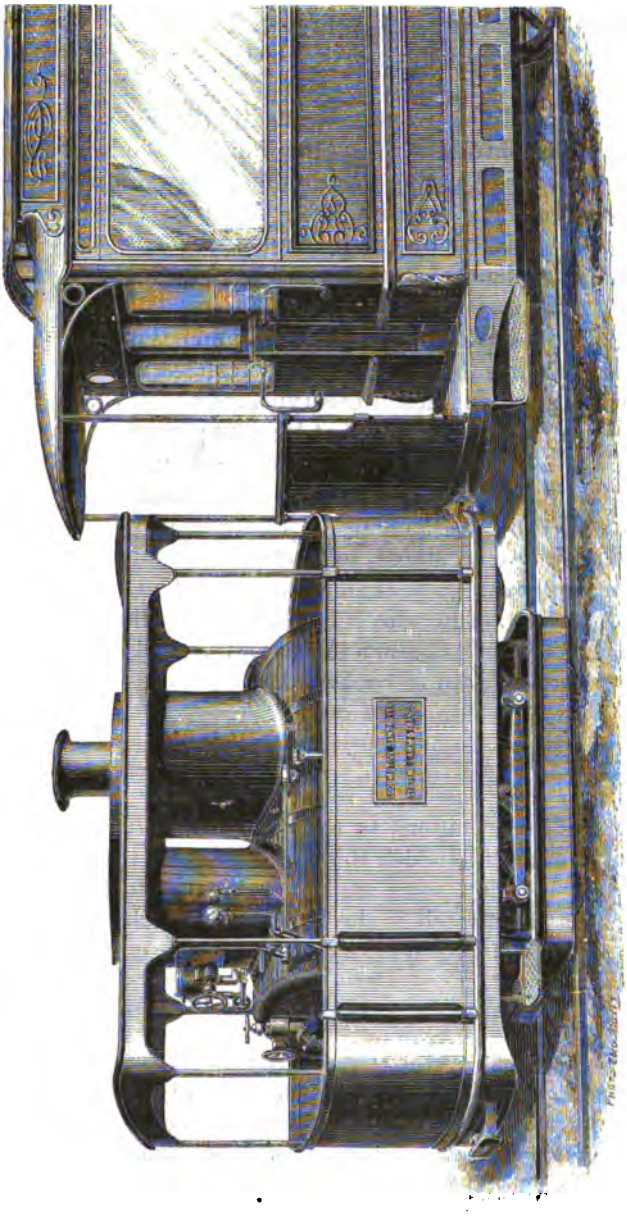


FIG. 14.—*Compressed air motor and street-car. System of Lamm & Francq.*

Lamm & Francq's street-car motor.

a quantity of steam equivalent at the least to the ninth part of the weight of the water. This steam disengages itself from the water as soon as a vent is presented for its escape,

Compressed-air motors.

and when permitted to discharge itself into the cylinders of a locomotive engine it will develop a very considerable tractive power (estimated at 1,800 kilo meters for each kilo of water used). In the engine exhibited the reservoir was designed to hold 400 gallons of water, into which was to be injected steam surcharged with heat until its temperature reached 200° centigrade.

System of Lamm & Francq. Figure 14.

Use in the environs of Paris.

The locomotive so charged has been used successfully upon the line of tramway from Reuil to Marly-le-Roi, in hauling two coaches carrying together 60 passengers, a distance of about ten miles, without being recharged; and this has been accomplished upon a line upon which it is said that there are gradients of 3 in 100, and not less than fifty curves having a minimum radius of 98 ft.

Economy compared with steam.

It is claimed that the experience upon this line has demonstrated that the saving actually realized by the employment of fireless engines of this type, instead of the ordinary steam-locomotives, has been at least 40 per cent.

Figure 14 represents the locomotive exhibited by the "Continental Company for the Manufacture of Fireless Locomotives." The 400 gallons of water which the reservoir holds is raised, as stated, to 200° centigrade (representing 15 atmospheres). The cylinders are 74″ in diameter by 8.125″ stroke. The wheels are 24.67″ in diameter. The weight of the machine is 6 tons, empty. It is designed to move either forward or backward.

Dimensions.

Having thus passed in rapid review some of the more important contributions to the Paris Exposition connected with the subject to which this report relates, I proceed now to briefly mention some matters belonging to the railway practice as illustrated at the Exposition which could not be well considered with relevancy in any other connection.

Brakes and signaling apparatus.

Brakes and apparatus for signaling trains.

Westinghouse brake.

There were several systems of railway brakes represented upon the cars and trains of cars at the Exposition. Of these the Westinghouse automatic brake, so well and favorably known in this country, was by common consent accorded the first place in point of excellence. It fulfills all of the conditions laid down by the highest railway authority in the best, the simplest, and the most effective manner yet attained by any apparatus introduced.

Conditions laid down by the British Board of Trade.

The British Board of Trade, after an exhaustive study and investigation of the subject, has laid down the following as the essential conditions of an effective continuous brake:*

(1) "The brakes to be efficient in stopping trains, instantaneous in their action, and capable of being applied without difficulty by engine-drivers or guards."

(2) "In case of accident, to be instantaneously self-acting."

(3) "The brakes to be put on and taken off with facility on the engine and every vehicle of the train."

(4) "The brakes to be regularly used in daily working."

(5) "The materials employed to be of a durable character so as to be easily maintained and kept in order."

Wide use and proof of the efficiency of the Westinghouse brake.

The Westinghouse brake has, by a long and thorough trial upon railroads in the United States and in Great Britain, France, Germany, Belgium, and the British colonies, established beyond controversy its satisfactory fulfillment of all of these requirements, and it must be conceded that no other brake yet introduced so well and so thoroughly meets them all. The advantages possessed by this admirable contrivance were illustrated by an excellent exhibit in the section of the United States, and also upon the cars exhibited by the Western Railway of France, but nowhere were its merits more happily illustrated than upon the Ceinture Railway at Paris. The hundreds of thousands of passengers who used that line in going to and from the Exposition and in going from point to point in the city and its environs had an excellent opportunity for observing its superb working, the smoothness, the ease, and yet the suddenness with which trains heavily loaded were stopped without a jar, and absolutely without any unpleasant oscillation or concussion, in a distance which a few years since would have been deemed incredibly short.

Exhibit on cars of the Western Railway of France.

Chemin de fer de Ceinture.

It is probable that this brake has been used upon no road anywhere more successfully than upon this metropolitan railway of Paris, and it is certain that no other similar appliance has anywhere accomplished such satisfactory results as have been there realized.

Railway signaling apparatus.

Signaling apparatus.

Saxby & Farmer.

In the design, construction, and efficient working of railway signaling apparatus Messrs. Saxby & Farmer, of Kilburn, London, England, have attained a pre-eminence of merit only equaled by that of the Westinghouse Air Brake Company in their special department.

The system of Messrs. Saxby & Farmer, designed and per-

* Circular of Board of Trade, London, August 30, 1877.

Signaling apparatus.

fected by their manager, Mr. Hodgson, combines the two systems known as the "block" and "interlocking" systems,

Block and interlocking systems.

in such manner that each is absolutely interdependent upon the other. The mechanical union of the two systems has

Mr. Hodgson.

been most ingeniously and thoroughly accomplished by Mr. Hodgson in this admirable invention. The apparatus is so contrived that the danger arising from a possible contradiction between the block telegraph signals transmitted from one station to another and the out-door signals exhibited to the engine-drivers seems to be practically and thoroughly obviated. This apparatus has been largely introduced upon the railways of Great Britain and the Continent of Europe, and has been, it is stated, adopted by the Pennsylvania Railroad Company, with very satisfactory results. It was illustrated

Exhibited at the Centennial.

by an exhibit at the Centennial Exhibition at Philadelphia in 1876, since which time it has been steadily growing in favor and in the appreciation of those who have studied its merits.

Efficiency.

It is certainly an admirable arrangement, and seems, so far as human contrivance can accomplish it, to absolutely remove all danger of accidents and collisions at station sarising from the carelessness, negligence, stupidity, or the misapprehension of the signalmen or the locomotive engineers.

It will be observed that this report has been confined almost entirely to the railway and tramway practice of transatlantic countries represented at Paris, and that but brief mention is made of a few exhibits in the classes covered by

Reasons for confining the report principally to foreign exhibits.

the report furnished from the United States. The reasons for this were two-fold: (1) The reading and thinking public in America is already so familiar with the features of the railway practice of this country that nothing would be added to the possible interest of such a paper as this by a discussion of American railway apparatus and appliances; and (2) the exhibits relating to this subject sent from the United States to the late Exposition were by no means fairly representative of the best American railway practice.

It is particularly to be regretted that the collection of American railway rolling stock, machinery, and material should have been so meager, and therefore so unsatisfactory. The machinery, vehicles, and practice adopted upon railroads and in the construction and working of railroads in the United States are, to a great extent, so different from those in use in the Old World, and in many particulars for the wants of a country like ours, and, it would seem, for vast sections of the eastern continents as well, are so superior to the systems, methods, and appliances generally in vogue

in Europe, that it would have been well for American manufacturers of railway rolling stock, machinery, and fixtures to have availed themselves of this fair opportunity for exhibiting the special merits of their machines, cars, and apparatus to the nations of the world. Certainly this country would have lost nothing by the comparison which would have thus been rendered practicable.

How interesting a full exhibit of railway apparatus might have been to Europeans.

The few exhibits of this class from the United States were, however, generally excellent of their kind. The Westinghouse brake has been already noticed, and brief mention has been made of the Pullman palace sleeping-car. This latter, a beautiful and admirably arranged vehicle, was the only railroad car furnished to the Exposition from the United States. It attracted the attention of many thousands of European visitors to the American section, and was greatly admired and commended by those familiar with the demands of modern railway travel. Indeed, no other passenger coach designed to be used as a sleeping car exhibited by any country equaled the cars of the Pullman system in comfort and convenience, the economy of space realized, and many other advantages which they possess in an eminent degree for the accommodation of passengers by day and by night.

Our exhibits excellent of their kind.

Westinghouse brake.

Pullman car.

Superior to any European cars.

The only locomotive from the United States was one of the ordinary powerful freight engines of the Philadelphia and Reading Railroad Company, adapted for the use of an thracite coals. It fairly illustrated the simplicity and excellence of a type of locomotive in use in this country.

Phila. & Reading Railroad locomotive.

The collections of cast-iron car wheels furnished by Messrs. A. Whitney & Sons, of Philadelphia, and by Messrs. Barnum, Richardson, & Co., of Lime Rock, Conn., are deemed worthy of special mention and commendation. These wheels, in point of strength, security, and durability, compared favorably with the best types of wrought-iron steel-tired wheels so largely used in Europe, and in point of cheapness of cost and economy realized in their use had greatly the advantage of the car wheels of the European systems.

Cast-iron car wheels.

A. Whitney & Sons.

Barnum, Richardson & Co.

In concluding this report I beg leave to acknowledge the valuable assistance afforded to me by Mr. E. R. Archer, M. E., of Richmond, Va., in prosecuting studies and investigations and obtaining data largely used in its preparation, and to the Commissioner-General, Mr. McCormick, for uniform courtesy and kindness and for such assistance as it was in his power to render me in the discharge of the duty to which I was assigned.

Acknowledgment.

Mr. E. R. Archer.

WILLIAM A. ANDERSON,
Additional Commissioner.

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NOTE.—*An asterisk* (*) *affixed to a reference signifies that an illustration occurs on the page named. The chemical substances referred to in this volume are too numerous to be repeated alphabetically; they are grouped in alphabetical order under the title* Chemistry and Pharmacy: products, by-products, materials.

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Bolivia,	Mexico,	Sweden,
Chili,	Monaco,	Switzerland,
China,	Morocco,	South America,
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Brazil,	Italy (with provinces),	Roumania,
Chili,	Japan,	Russia (with provinces),
China,	Lapland,	Spain (with colonies),
Denmark,	Luxemburg,	Sweden,
Egypt,	Malacca,	Turkestan,
France (with colonies),	Mexico,	Turkey,
Germany (with individual states),	Netherlands (with colonies), New Grenada,	United States (with individual states).

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Alabama,	Idaho,	Tennessee,
Arizona,	Montana,	Utah,
California,	New Mexico,	Virginia,
Colorado,	North Carolina,	Washington Territory,
Dakota,	Oregon,	Wyoming.]
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